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In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

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Reports

Radiobioassay Program of the Institutional Total Diet Sampling Network
II. Selected Physiological Constants of Urine

A. A. Moghissi and Mary G. Mayes [1]

The Institutional Total Diet Sampling Network program, initiated in 1961, has provided information on the intake of certain radionuclides by selected groups of children and young adults, and the resulting radiation dose. Starting with 1966, this was supplemented by a radiobioassay program with the aim of improving radiation dose estimates by using excretion data. Numerous physiological parameters were measured to evaluate their suitability for the validation of a 24-hour urine sample.

The results of measurements of volume, specific gravity, pH value, osmolality, and creatinine in samples collected during 1966–1968 are summarized. Results of these measurements, along with a review of available data, with particular emphasis on creatinine, are presented and discussed.

The Institutional Total Diet Sampling Network program (ITDSN) is described in an earlier report (*1*). In initiating a radiobioassay program in 1966, 10 of the stations (figure 1) were selected for special sampling and determination of urinary constants. The analytical data for this program have been reported (*2*).

By examining the data from urine samples in correlation with food intake values, a better evaluation of the possible radiation hazard was anticipated. A brief description of the radiobioassay program of the ITDSN, and preliminary findings related to cesium-137 (*3*) and tritium (*4*), were previously reported.

Our investigations of the physiological constants will be described below. For convenience, the description of physiological constants reported by other authors will be discussed as well, under the headings for the specific constants.

Procedures and methods

The details of the sample collection and analytical procedures were reported previously (*3*). These have been modified slightly during the course of operation of the program.

The volume, specific gravity, and pH of the samples were determined by conventional techniques. Osmolality was determined by means of an osmometer manufactured by Advanced Instrument, Inc.[2] The standard provided by the manufacturer consisted of a sodium chloride solution containing colloids, to simulate biological specimens.

Creatinine was analyzed by the Folin (*5*) technique as modified by Clark and Thompson (*6*). Various substances, including certain drugs, glucose, acetone, and acetoacetic acid, may affect the accuracy of the analysis (*6–8*).

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[1] National Environmental Research Center—Las Vegas, Environmental Protection Agency, Las Vegas, Nev.

[2] The use of the names of proprietary firms or products does not imply endorsement by the Environmental Protection Agency.

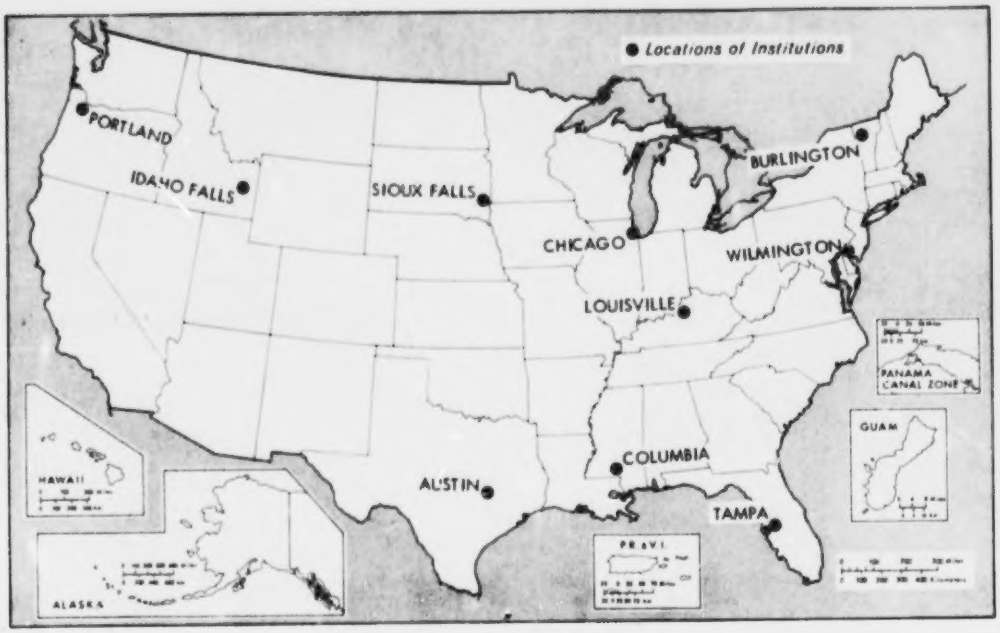

Figure 1. Locations of institutions

None of these is ordinarily present to any significant extent in the urine of healthy individuals; hence, no known discrepancies were due to these factors in this study.

The results of early experiments in this laboratory indicated that substantial errors were introduced if urine specimens were improperly preserved; therefore, particular attention was given to the preservation and handling of the 24-hour urine samples.

Results and discussion

Urinary constants were measured for their contribution to the validation of a 24-hour sample. The normal values for many of these parameters, particularly under conditions of this study, were largely unknown. It was hoped that information gained by combination of these parameters could be used to establish the validity of values reported.

In all cases, the values were separately averaged for males and females and for various ages. Values below 1 standard deviation from the mean were discarded but those above 1 standard deviation were retained. It was reasoned that excessively high values were probably caused by physiological factors while excessively low values were indicative of an incomplete sample collection. Obviously, this approach is subject to dispute. However, as can be seen in the majority of the cases studied, the cause for discarding a sample was that more than one factor, e.g., creatinine and volume, did not meet the criteria mentioned above.

Creatinine

The use of creatinine values for the validation of a 24-hour urine sample has been reported in the past (*9–12*). Creatinine is the end product of creatine catabolism, and excreted creatinine is a measure of the basal nitrogen catabolism. An adult man excretes 3 to 6 percent of total urinary nitrogen daily as creatinine, and the creatinine excretion is relatively constant from day to day for a given individual on a normal diet. However, several factors may affect creatinine excretion. For example, a heavy meat diet contains significant amounts of creatinine, which is not metabolized and is excreted rapidly. Creatinine in the diet is excreted unchanged in urine.

The constancy of true or endogenous creatinine excretion in the urine is not affected significantly by moderate changes in protein intake. However, creatinine in urine of persons on a normal diet may be elevated when renal function is impaired, as it depends on rate of urine formation and rate of elimination of urine. Serious renal impairment is indicated, for example, in disease states such as typhoid, tetanus, or pneumonia, where an increase in creatinine excretion would occur. A decrease in urinary creatinine would be observable in muscular atrophy, anemia, kidney degeneration, and leukemia. It is stressed, however, that measurements outside normal ranges do not necessarily indicate disease.

Creatinine excretion increases with age to adulthood, and is somewhat higher in obese persons than in thin persons (*13–15*). The creatinine measurement has been proven to be of greatest value in determining the completeness of urinary output and provides an index of glomerular filtration.

The problem of the validation of a 24-hour urine sample was complicated in this study by lack of control during sample collection and shipment. Although attempts have been made to relate urinary excretion rate to the creatinine level of a one-voiding sample (*10*), this approach would be questionable without reference to other criteria for children of the age groups of this study due to rapid changes in the metabolism of this age group.

Cahill and Wheeler (*3*) report normal creatinine values ranging from 0.4 to 1.7 g/day for children. Values of Clark, et al. (*16*), range from 0.50 to 1.90 g/day for ages 6 to 18. O'Brien and Abbott (*17*) related creatinine excretion to body weight of children, ages 12 to 17 as follows: females, 22.8 mg/kg (range 12.2–29.4); males, 25.1 mg/kg (range 20.7–28.2).

Klimakova (*18*) reported creatinine excretion values for 118 children, ages 7 to 16, on a special diet in which eggs, milk and curd replaced meat and fish. During maturation

Table 1. Creatinine in urine excreted by children
(g/day)

Age	Male								Female							
	Number of samples	High	Low	Mean	Standard deviation	Others		Reference	Number of samples	High	Low	Mean	Standard deviation	Others		Reference
						Mean	Standard deviation							Mean	Standard deviation	
7	3	0.55	0.20	0.33	0.19			(a)								
						0.50	0.10	16						0.54	0.12	16
8	7	.95	.29	.54	.22			(a)	1			0.81				(a)
9	24	1.52	.20	.72	.30			(a)	4	1.06	0.45	.67	0.31			(a)
						.69	.11	16						.59	.11	16
10	38	2.76	.14	.69	.48			(a)	10	1.22	.27	.61	.28			(a)
7–10						.48		18						.43		18
11	62	2.28	.04	.76	.40			(a)	24	1.34	.19	.60	.30			(a)
					.45	.21		19						.30	.15	19
					.83	.19		16						.80	.17	16
12	55	2.25	.05	.80	.44			(a)	18	2.78	.47	.97	.51			(a)
					.52	.23		19						.40	.27	19
13	12	1.52	.28	.76	.43			(a)	11	1.53	.32	.97	.36			(a)
						.66	.30	19						.33	.18	19
						.10	.29	16						.95	.19	16
1–13						.73		18						.70		18
14	16	4.51	.37	1.76	.98			(a)								
						.68	.36	19						.43	.36	19
15	45	3.69	.19	1.42	.74			(a)	2	1.29	.99	1.14	.21			(a)
						.86	.31	19						.48	.17	19
						1.50	.32	16						1.20	.18	16
16	57	2.81	.15	1.46	.55			(a)								
						.83	.34	19						.55	.24	19
14–16						1.08		18						.98		18
17	56	2.92	.08	1.38	.57			(a)								
						1.90	.32	16						1.20	.18	16
17–18						.85	.38	19						.60	.28	19
18	4	2.00	1.70	1.70	.22			(a)								

[a] This paper.

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daily urinary creatinine excretion increased. Contrasting results were obtained from 10 physically underdeveloped children. The urinary creatinine excretion of this group was lower than that of healthy children of the same age group. This study indicates the effect of nutrition and diet on urinary creatinine values, tends to explain the wide range of observed values.

Zorab (*19*) found that in children of both sexes, the mean creatinine excretion increased steadily with age, and between 11 and 18 years, the value doubled. Zorab's measurements were obtained from over 1,000 samples from children on a 24-hour collagen-free diet (withholding of ice cream, fish and meat). Banchieri (*20*) concluded that creatinine excretion is solely a function of body weight.

Table 1 shows the creatinine content of the samples collected, expressed as average value, range, and standard deviation. Figure 2 reflects graphically the data plotted by age and sex. For comparison, the figure also includes data from selected authors who have reported creatinine values for children (*16,18,19*). The data indicated no distinct influence of sex in early years, but an apparent divergence in later years of youth. Harding and Gaebler (*9*) previously reported this divergence in creatinine values during the teen years.

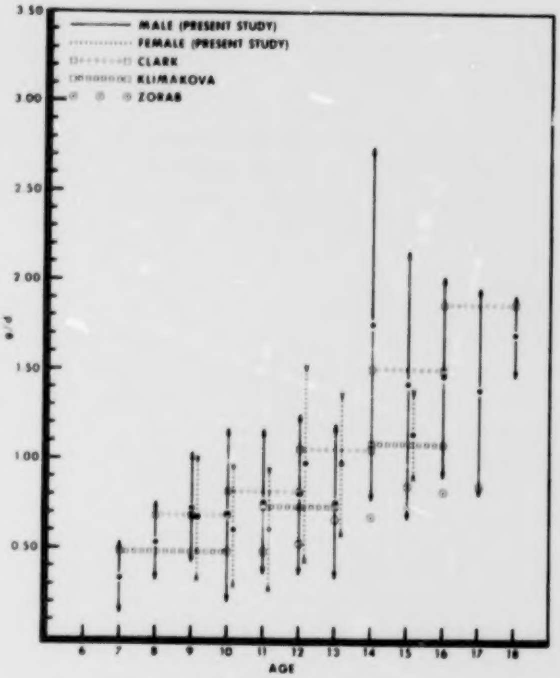

Figure 2. Urinary creatinine observations of childern 7 to 18 years, compared with mean value reported by Clark and Thompson (*16*), Klimakova (*18*), and Zorab (*19*), (mean and mean ± standard deviation)

Volume

Although urine volume alone is an unreliable parameter for the validation of a sample, in combination with other parameters it is useful (*7, 19, 22*). Table 2 lists the volumes of urine collected in this study. Plotting of the data by age (figure 3) indicates little deviation from values reported previously. Normal urine volume for children 5 to 8 years of age as reported by Nelson, et al. (*24*), is 650–1,000 ml/day; for 8 to 14 years of age, 800–1,000 ml/day. Rourke, et al. (*25*), reported average values of 1,200 ml/day, ranging from 500–3,000 ml/day.

In some cases, a very low creatinine value is associated with a small sample volume, indicating an incomplete collection. There are also examples of disagreement between the two parameters. A large sample volume and a small creatinine value could be attributed to a possible addition of water to the sample by the child to satisfy the person in charge of the institution, and a reasonable creatinine value with a small sample volume may be attributed to a decrease in the water intake of the individual. In this report, samples having a volume lower than the mean less 1 standard deviation have been eliminated from further evaluation. In the majority of cases, these samples would also have been disregarded due to the low creatinine content.

Covariance analysis was performed where the volume of each sample was related to the creatinine value obtained. The resulting coefficients were plotted by age and sex. Figure 4 indicates that this relationship increases with age.

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Table 2. Volume of urine excreted by children (ml/day)

	Male					Female				
Age	Number of samples	High	Low	Mean	Standard deviation	Number of samples	High	Low	Mean	Standard deviation
7	3	790	455	680	190	—	—	—	—	—
8	7	900	150	560	260	1	—	—	430	—
9	27	2,000	170	640	380	4	1,760	480	940	550
10	43	1,820	125	700	360	12	1,300	240	710	330
11	64	1,580	90	730	380	25	1,300	120	610	340
12	59	2,082	120	840	460	18	1,900	390	890	380
13	12	3,400	150	1,200	1,000	12	1,340	440	840	290
14	21	3,888	660	1,400	760	—	—	—	—	—
15	45	2,252	415	1,200	490	2	650	620	640	210
16	59	3,075	425	1,200	550	—	—	—	—	—
17	60	3,580	360	1,200	750	—	—	—	—	—
18	4	2,900	900	1,700	960	—	—	—	—	—

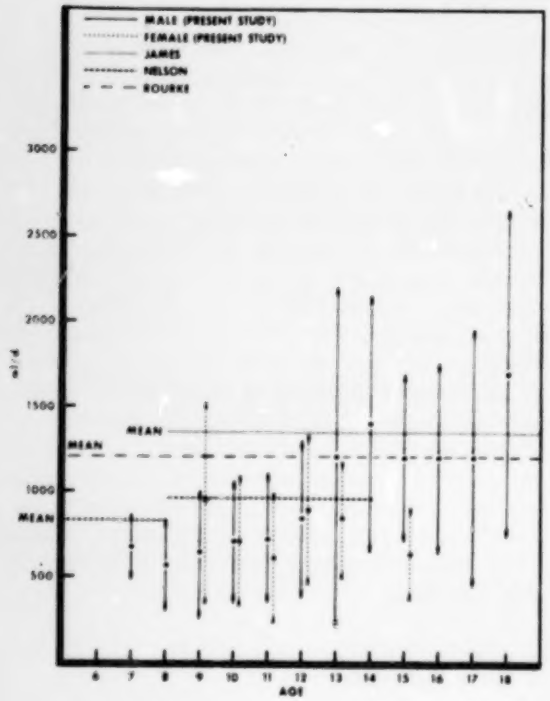

Figure 3. Results of urine volume measurements of children 7 to 18 years, compared to mean value reported by James (*23*), Nelson et al. (*24*), and Rourke et al. (*25*) (mean and mean ± standard deviation)

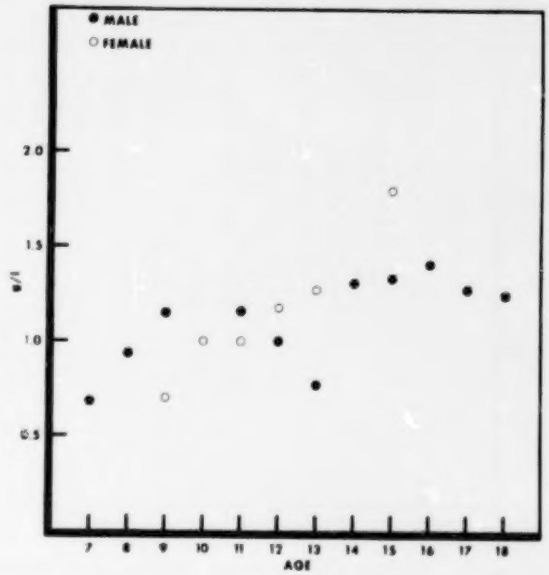

Figure 4. Excretion of creatinine by children expressed in g/liter

Specific gravity and osmolality

Normal specific gravity measurements fall in the range of 1.002–1.025, with the average value at 1.018 for children (*22–26, 27*). Table 3 lists the specific gravity determinations and figure 5 shows them graphically. The stability of the specific gravity in urine is remarkable and in combination with other parameters such as volume, is used to validate the sample. A high volume and a low specific gravity indicate a possible dilution of the sample with water. In several cases, this could be observed and was combined with a low creatinine value. The combination of volume and specific gravity could be used only on a confirmatory basis as high water excretion is usually associated with low salt concentration.

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Table 3. Specific gravity of urine excreted by children

Age	Male: Number of samples	Male: High	Male: Low	Male: Mean	Male: Standard deviation	Female: Number of samples	Female: High	Female: Low	Female: Mean	Female: Standard deviation
7	3	1.033	1.015	1.023	0.009	—	—	—	—	—
8	7	1.034	1.018	1.027	.006	1	—	—	1.021	—
9	27	1.032	1.015	1.022	.005	4	1.025	1.014	1.019	0.004
10	43	1.033	1.010	1.021	.005	12	1.032	1.005	1.020	.007
11	64	1.035	1.005	1.022	.007	25	1.032	1.010	1.022	.006
12	59	1.030	1.009	1.020	.005	18	1.030	1.009	1.021	.004
13	12	1.030	1.006	1.018	.007	12	1.029	1.017	1.022	.005
14	21	1.030	1.010	1.019	.006	—	—	—	—	—
15	45	1.035	1.004	1.019	.008	2	1.034	1.032	1.033	.001
16	59	1.033	1.004	1.021	.006	—	—	—	—	—
17	60	1.035	1.002	1.020	.007	—	—	—	—	—
18	4	1.030	1.010	1.021	.008	—	—	—	—	—

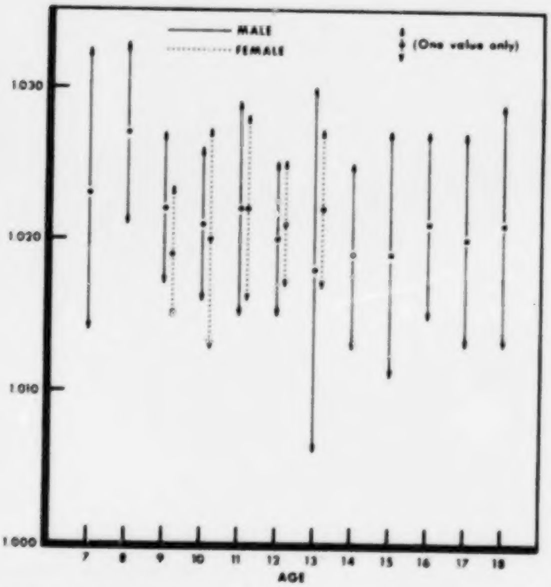

Figure 5. Specific gravity results in urine of children 7 to 18 years (mean and mean ± standard deviation)

Closely associated with specific gravity is the osmolality. By definition, the osmolality of a given solution is numerically equal to the molality of an ideal solution of a nonelectrolyte having the same freezing point. Korte (*28*) suggested that since the osmolality of urine is influenced by the intake of electrolytes and the content of nitrogen-containing compounds in urine, osmolality ratios in nutritional field studies may prove to be more constant than creatinine values which are dependent on muscle mass development. This observation was based on the fact that the intake and output of electrolytes are well balanced and constant in most communities of developing countries.

Osmolality results of this study are shown in table 4. Graphic presentation of the data is shown in figure 6. Normal osmolality measurements range from 515 mOs/liter for infants to an average value of 1,362 for 14 to 18-year olds (*29, 30*).

Table 4. Osmolality of urine excreted by children (mOs/liter)

Age	Male: Number of samples	Male: High	Male: Low	Male: Mean	Male: Standard deviation	Female: Number of samples	Female: High	Female: Low	Female: Mean	Female: Standard deviation
7	3	1,250	613	860	340	—	—	—	—	—
8	4	995	824	920	73	1	—	—	770	—
9	15	1,950	500	880	400	3	809	522	660	140
10	26	1,700	190	790	340	2	3,200	814	2,000	1,700
11	41	3,100	171	1,1[illegible]0	700	8	2,750	699	1,300	720
12	19	1,035	348	700	190	12	1,150	640	800	150
13	10	1,125	275	680	290	3	1,600	791	1,100	430
14	12	1,800	210	800	470	—	—	—	—	—
15	25	3,300	210	830	750	2	3,100	1,500	2,300	1,130
16	32	1,950	110	760	390	—	—	—	—	—
17	36	2,900	130	830	640	—	—	—	—	—
18	2	650	303	480	240	—	—	—	—	—

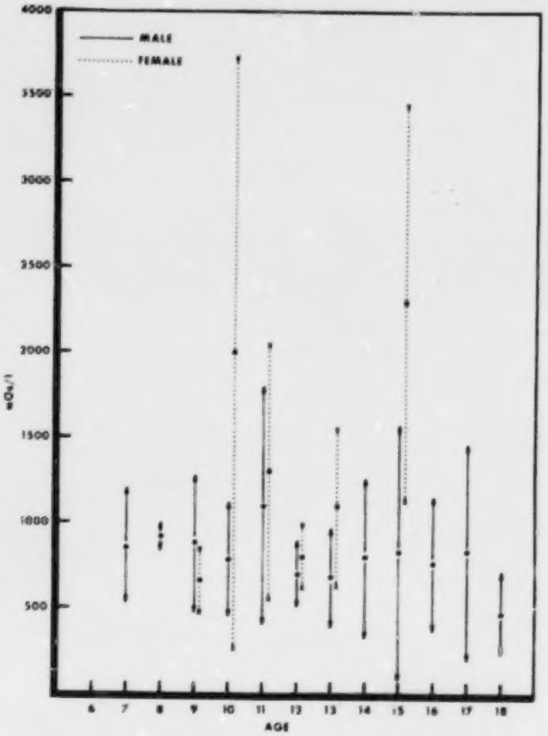

Figure 6. Osmolality in urine of children 7 to 18 years (mean and mean ± standard deviation)

pH Value

Because the pH value changes with metabolism and biological activity after the sample collection, conclusions regarding the relationship between the pH value and the validity of the sample are dubious. In the present study an attempt was made to properly preserve the samples and thus the pH values may be of greater value than from improperly preserved samples. The determination of urinary pH is of importance clinically, largely in relation to the precipitation of insoluble material from urine and possible formation of urinary calculi. The normal pH range values for man are 4.8 to 8.0 (*25*). Table 5 and figure 7 include the pH observations for ages 6 to 18 in this study and indicate agreement with previously reported values.

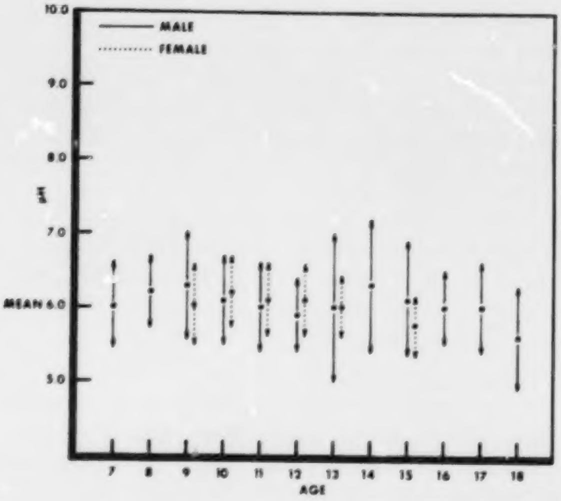

Figure 7. Urine pH measurements of children 7 to 18 years (mean and mean ± standard deviation)

Table 5. pH of urine excreted by children

	Male					Female				
Age	Number of samples	High	Low	Mean	Standard deviation	Number of samples	High	Low	Mean	Standard deviation
7	3	6.7	5.7	6.03	0.58	—	—	—	—	—
8	8	6.6	6.1	6.23	.49	1	—	—	6.40	—
9	25	9.0	5.4	6.28	.74	4	6.6	5.4	6.05	0.59
10	41	7.9	4.8	6.07	.61	10	6.9	5.3	6.19	.46
11	61	8.4	5.0	5.98	.55	23	6.8	5.4	6.13	.42
12	53	7.0	4.5	5.85	.56	18	6.8	5.3	6.14	.46
13	12	8.8	4.9	6.0	1.0	11	6.7	5.6	6.03	.34
14	17	9.7	5.6	6.29	.94	—	—	—	—	—
15	45	9.8	5.0	6.09	.83	2	6.0	5.5	5.75	.35
16	58	7.0	5.0	6.00	.48	—	—	—	—	—
17	58	8.3	5.0	6.02	.60	—	—	—	—	—
18	4	6.2	4.8	5.58	.68	—	—	—	—	—

Conclusions

It is evident that the measurement of urinary parameters is valuable for radiobioassay studies in children. Creatinine determination has been used in the present study as the most important single factor in the validation of a 24-hour urine sample.

Volume, osmolality, and specific gravity are other useful parameters which were used to confirm conclusions based on creatinine values. The pH determination was performed to evaluate the condition of urine and, in some instances, as a basis for elimination of sample data obtained from children with health disorders. The combined values determined for these samples indicate that a 24-hour sample can be validated, provided previously reported data are used in combination as "normal values." Sixty-two samples were eliminated from consideration on the basis of a combination of constants, 14 on the basis of volume alone, and 27 solely on the creatinine value.

Upon further investigation, the use of osmolality as a urinary constant may prove to be of greater value than considered here although insufficient data were available for a conclusive evaluation.

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REFERENCES

(*1*) ANDERSON, E. C. and D. J. NELSON, JR. Surveillance for radiological contamination in food. Amer J Pub Hlth 52:139 (1962). See also *Radiation Data and Reports* for continuous updating of ITDSN.

(*2*) MOGHISSI, A. A., M. W. CARTER, and R. LIEBERMAN. Radiobioassay program of the Institutional Total Diet Sampling Network—I. Analytical data related to samples collected during 1966–1968. Radiat Data Rep 14:129–144 (March 1973).

(*3*) CAHILL, D. F., and J. K. WHEELER. The biological half-life of cesium-137 in children, determined by urinary assay. Health Phys 14:293–297 (1968).

(*4*) MOGHISSI, A. A., and R. LIEBERMAN. Tritium body burdens of children, 1967–1968. Radiol Hlth Data Rep 11:227–231 (May 1970).

(*5*) FOLIN, O. Determination of creatinine and creatine in urine. J Biol Chem 17:469 (1914).

(*6*) CLARK, L. C., JR., and H. L. THOMPSON. Determination of creatine and creatinine in urine. Anal Chem 21:1218 (October 1949).

(*7*) WATKINS, P. J. The effect of ketone bodies on the determination of creatinine. Clin Chem Acta 18:191 (1967).

(*8*) HUSDAN, H., and A. RAPOPORT. Estimation of creatinine by the Jaffe reaction. Clin Chem 14:322 (March 1968).

(*9*) HARDING, V. J., and O. H. GAEBLER. On the constancy of the creatine-creatinine excretion in children on a high protein diet. J Biol Chem 54:579 (1922).

(*10*) JACKSON, S. Creatinine in urine as an index of urinary excretion rate. Health Phys 12:843 (1966).

(*11*) EDWARDS, O. M., R. BAYLISS, and S. MILLEN. Urinary creatinine excretion as an index of the completion of 24-hour urine collections. Lancet 2: 1165–1166 (1969).

(*12*) HAMBURGER, J. Nephrology, Chapter 5. W. B. Saunders Company, Philadelphia (1968).

(*13*) CHINN, K. S. K. Prediction of muscle and remaining tissue protein in man. J Appl Physiol 23:713 (1967).

(*14*) BEHRENDT, H. Creatine and creatinine in diagnostic tests in infants and children. Lea and Febiger, Philadelphia (1962) pp. 162–167.

(*15*) NOVAK, L. P. Age and sex differences in body density and creatinine excretion of high school children. Ann N.Y. Acad Sci 110:545–577 (1963).

(*16*) CLARK, L. C., H. L. THOMPSON, E. I. BECK, and W. JACOBSON. Excretion of creatine and creatinine by children. Amer J Dis Child 81:774 (1951).

(*17*) O'BRIEN, B., and F. A. ABBOTT. Creatinine and creatine in urine. Laboratory Manual of Pediatric Micro and Ultramicro Biochemical Techniques, 3rd Edition. Harper and Row Company, New York (1962) p. 100.

(*18*) KLIMAKOVA, A. I. Creatinine metabolism as a development index of the muscular system in children. Tr Nauchn Konf Po Vozrastnoi Morfol, Fiziol i Biokhim, 6th:336, Moscow (1965).

(*19*) ZORAB, P. A. Normal creatinine and hydroxyproline excretion in young persons. Lancet 2:1164 (1969).

(*20*) BANCHIERI, G. C. Creatininuria and creatinuria in relation to age, sex, and various pathological conditions. Giorn Gerontol 16:653–664 (1968).

(*21*) OAKLEY, B. W. Urinary excretion rates of creatinine, UKAEA Document AERE MED/R 2098 (1956).

(*22*) ELKINS, H. B. The specific gravity adjustment in urinalysis. Arch Environ Hlth 18:996–1001 (1969).

(*23*) JAMES, J. A. Renal disease in childhood, Chapter 5. C. V. Mosby Co., St. Louis, Mo. (1968).

(*24*) NELSON, W. E., V. C. VAUGHAN, III, and R. J. McKAY, Eds. Textbook of Pediatrics, 9th Edition. W. B. Saunders, Philadelphia (1969) p. 210.

(*25*) ROURKE, G. M., E. A. MacLACHLAN, and A. M. BUTLER. Case records of the Massachusetts General Hospital normal laboratory values. New Eng J Med 234:24 (1946).

(*26*) MERRILL, J. P. Normal and abnormal renal function. Urology, 2nd Edition. W. B. Saunders and Company, Philadelphia (1963) p. 51.

(*27*) Massachusetts General Hospital "normal values." New Eng J Med 283:1279 (1970).

(*28*) KORTE, R. Urinary creatinine excretion. Amer J Clin Nutr 23:868 (July 1970).

(29) POLACEK, E. The osmotic concentration ability in healthy infants and children. Arch Dis Child 40:211, 291–295 (1965).

(*30*) CORCORAN, A. C. Electrometrics urinometry: a note on comparative determinations of urinary osmolarity and specific gravity. J. Lab Clin Med 46:141 (1955).

Radiobioassay Program of the Institutional Total Diet Sampling Network III. Cesium-137 Dose Estimates and Body Burdens of Children

A. A. Moghissi and Mary G. Mayes [1]

Food and urine samples collected from ten stations of the Institutional Total Diet Sampling Network program were analyzed. Cesium-137 and potassium in food and urine were analyzed by gamma spectroscopy. The cesium-137 body burdens were established by using the cesium-to-potassium ratio, by the relationship between cesium content of urine and the biological half-life of cesium in children, and by a model based on intake.

Differences among results obtained, using each of these techniques, are discussed. Radiation dose calculations are based on recommendations in International Commission on Radiation Protection Report Number 2.

A description, discussion of objectives, and the analytical results of the Institutional Total Diet Sampling Network (ITDSN) program have been published and are continuously updated (*1*). Also, essential features of the radiobioassay portion of the ITDSN program have been described (*2-4*). Data concerning the urinary constants measured during the years 1966–1968 are detailed in this issue of *Radiation Data and Reports.* (*5*). This report deals with the discussion of the results of studies on the cesium-137 body burdens of children, and the resulting radiation dose to muscle, liver, and bone.

Since intake and urinary excretion data on a large number of subjects within the ITDSN have been determined, an opportunity is provided for estimating the cesium-137 body burden by a variety of calculation techniques.

Rehnberg, et al., (*6*) have estimated the body burden of children using the following equation:

$$Q = 10^{-3} f \sum_{i=1}^{i=n} I^{t_b/0.693} (1 - e^{-0.693\, t_m/t_b})\, e^{-0.693\, t_d/t_b} \qquad \ldots (1)$$

where: Q = the cesium-137 body burden in nCi,

f = the fraction of cesium-137 absorbed from the GI tract,

I = the intake of cesium-137 per day,

t_b = the biological half-life of cesium,

t_m = the reporting period for intake values (1 month), and

t_d = the period between end of ith period and period of the body burden estimation.

The available total diet results permit an estimation of the body burden using equation (1).

A second possibility for the estimation of body burden is the application of the following equation:

$$t_b = 0.693\, Q \frac{F_u}{U} \qquad \ldots (2)$$

where:

Q and t_b have the same notations as in equation (1),

F_U = the fraction of cesium-137 excreted in urine, and

U = the average cesium-137 activity in urine in nCi/day.

The estimation based on equation (2) is particularly useful as the t_b of 53 days was determined (*2*) using the same procedures employed to obtain data from the subjects covered by this study.

Several investigations have compared the $^{137}Cs/K$ in food to that in the body. McNeill and Trojan (*6*), e.g., propose the following equation:

$$(^{137}Cs/K)_{body} = 3\,(^{137}Cs/K)_{food} \qquad \ldots (3)$$

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Oberhausen and Onstead (*7*) have measured the potassium values in children. Their extensive values are generally in agreement with previously reported results (*8*). Using those results and $(^{137}Cs/K)_{body}$, the body burden can be estimated.

The comparison between the results from the three above-mentioned methods permits an evaluation of errors associated with cesium body burden determinations in children by methods other than the direct measurement, i.e., whole body counting.

Based on the body burdens estimated and reported in this paper, dose estimates were calculated according to the International Commission on Radiation Protection (ICRP) model (*9*) and are presented following body burden information.

Procedures and methods

The details of sample collection and analysis, dietary habits and other factors influencing the cesium intake in the ITDSN have been described previously (*1*). The radiobioassay portion of ITDSN for 1966, including the details and analysis and the procedures for validation of 24-hour urine samples, was reported by Cahill and Wheeler (*2*). These procedures have continued to be followed except for the addition of an osmolality factor. Considerable effort was made to validate the 24-hour urine collection. The highest reliance was placed on creatinine content as this parameter seems to be relatively independent of the intake. Volume, pH-value, and specific gravity were used as supplementary evidence (*4*). All samples were analyzed by gamma spectroscopy as previously described (*2*).

Results and discussions

Tables 1 to 3 show the body burdens of children from selected institutions in the United States during 1966 to 1968.

Table 1. Cesium-137 body burden of children during 1966 (nCi)

Station		t_b [a]	Cs/K [b]	F [c]	Average
Tex:	Austin	[d](11) 1.5	1.2	1.6	1.4
Miss:	Columbia	4.4	—	—	4.4
Del:	Wilmington	(10) 3.4	1.9	(11) 3.9	3.1
Idaho:	Idaho Falls	(10) 4.0	4.2	5.0	4.4
Vt:	Burlington	(11) 3.4	2.9	3.3	3.2
Oreg:	Portland	(9) 5.4	5.8	(11) 4.4	5.2
Ky:	Louisville	(7) 2.5	1.8	(10) 2.3	2.2
Ill:	Chicago	3.2	2.4	2.7	2.8
S. Dak:	Sioux Falls	(6) 2.7	3.3	(6) 6.6	4.2
Fla:	Tampa	(11) 7.2	4.0	9.9	7.0
Average		3.8	3.0	4.4	

[a] Calculated by the biological half-life.
[b] Calculated by the cesium-to-potassium ratio.
[c] Calculated from the food intake.
[d] Number of months per year for which samples were available.

Table 2. Cesium-137 body burden of children during 1967 (nCi)

Station		t_b [a]	Cs/K [b]	F [c]	Average
Tex:	Austin	1.0	0.4	0.1	0.50
Miss:	Columbia	2.3	—	—	2.3
Del:	Wilmington	2.5	.9	1.7	1.7
Idaho:	Idaho Falls	3.0	1.7	2.1	2.3
Vt:	Burlington	[d](6) 1.0	1.1	(8) 2.2	1.4
Oreg:	Portland	2.9	2.5	2.5	2.6
Ky:	Louisville	(11) .8	.7	.4	.6
Ill:	Chicago	(11) 2.0	1.2	2.0	1.7
S. Dak:	Sioux Falls	—	—	—	—
Fla:	Tampa	(11) 3.4	2.2	7.3	4.3
Average		2.1	1.3	2.3	

[a] Calculated by the biological half-life.
[b] Calculated by the cesium-to-potassium ratio.
[c] Calculated from the food intake.
[d] Number of months per year for which samples were available.

Table 3. Cesium-137 body burden of children during 1968 (nCi)

Station		t_b [a]	Cs/K [b]	F [c]	Average
Tex:	Austin	—	—	—	—
Miss:	Columbia	2.1	1.8	1.8	1.9
Del:	Wilmington	[d](11) 1.2	.4	.7	.8
Idaho:	Idaho Falls	(11) 3.4	2.0	3.0	2.8
Vt:	Burlington	—	—	—	—
Oreg:	Portland	3.2	1.7	(1) 1.2	2.0
Ky:	Louisville	1.1	—	—	1.1
Ill:	Chicago	(6) 1.2	1.2	(6) 1.8	1.4
S. Dak:	Sioux Falls	—	—	—	—
Fla:	Tampa	(1) 2.7	1.8	3.4	2.6
Average		2.1	1.5	2.0	

[a] Calculated by the biological half-life.
[b] Calculated by the cesium-to-potarsium ratio.
[c] Calculated from the food intake.
[d] Number of months per year for which samples were available.

The body burden estimation by the biological half-life method is reported under t_b and was calculated according to equation (2) using a urine to total excretion ratio of 0.8 (*2*) and a t_b of 53 days.

The body burden by food intake (F) was calculated using equation (1). Due to the incomplete sample collection during the year, the average value for each year was used in the calculation process to replace the missing months. The application of equation (3) in association with potassium values is reported in the column designated Cs/K. Finally, the average of the results obtained by three methods is also included.

It can be seen that the deviation of the results of each method from the average is reasonably small if one considers the errors associated with this type of study. The largest errors are introduced by the low levels of cesium in food and urine and large analytical errors associated with some of the results.

An additional source of error in the results obtained from the cesium to potassium ratio is the uncertainty regarding the potassium body burden of children. Obviously, the average potassium values used for the calculation can deviate markedly from the potassium body burden of children in this study.

All cesium-137 results below the minimum limit of detection of 10 pCi/kg were recorded as zero. It is obvious that this procedure causes discrepancies in individual results. During the averaging process, these inaccuracies tend to be minimized and thus the calculated annual average body burdens by the biological half-life method and the food intake method agree reasonably well. For 1966, the values were 3.8 nCi and 4.4 nCi, respectively. For 1967, these values were 2.1 nCi and 2.3 nCi, and for 1968, 2.1 nCi and 2.0 nCi. The values calculated from the cesium-to-potassium ratio for the same years are 3.0 nCi, 1.3 nCi, and 1.5 nCi, respectively. These averages are lower than values calculated by other techniques, although in no case do they deviate by more than a factor of 2 from values calculated by the two other methods.

Results obtained from the Austin station in 1967 are indicative of the effect of the analytical errors. While all urine values were above the minimum limit of detection, six food values were below the limit of detection and thus were recorded as zero. This explains the 10-fold difference between the body burdens estimated by the biological half-life and food intake methods, respectively.

It is concluded that the body burden estimation by any one of the above mentioned techniques is valid for the evaluation of population exposure provided a sufficiently large number of samples are available. In many cases, the whole body counting technique is not sensitive enough to measure the body burden in the general population and one is forced to use techniques based on intake or excretion. If reasonable sample collection and analytical techniques are used, the results of these cesium body burden estimates are valid and are accurate within a factor of 2 or less.

Table 4 summarizes the results of dose estimates by geographic location and by year using the ICRP model (*9*).

Table 4. Average estimated dose from cesium-137 by geographic location (mrem/a)

Location	Tissue	1966	1967	1968
Tex: Austin	Muscle	0.8	0.3	NA
	Liver	1.2	.4	NA
	Bone	.6	.2	NA
Miss: Columbia	Muscle	1.5	.8	0.6
	Liver	2.1	1.1	.9
	Bone	1.1	.5	.5
Ky: Louisville	Muscle	1.0	.3	.6
	Liver	1.5	.4	.9
	Bone	.7	.2	.4
Ill: Chicago	Muscle	1.3	.8	.7
	Liver	1.9	1.2	1.0
	Bone	1.0	.6	.5
S. Dak: Sioux Falls	Muscle	2.2	NA	NA
	Liver	3.1	NA	NA
	Bone	1.6	NA	NA
Del: Wilmington	Muscle	1.7	.9	.5
	Liver	2.3	1.3	.7
	Bone	1.2	.7	.3
Idaho: Idaho Falls	Muscle	1.5	.8	1.0
	Liver	2.1	1.1	1.4
	Bone	1.1	.6	.7
Vt: Burlington	Muscle	1.7	.7	NA
	Liver	2.4	1.1	NA
	Bone	1.2	.5	NA
Oreg: Portland	Muscle	1.8	.9	.7
	Liver	2.5	1.3	1.0
	Bone	1.3	.7	.5
Fla: Tampa	Muscle	3.7	2.3	1.5
	Liver	5.3	3.3	2.1
	Bone	2.7	1.7	1.1

NA, no analysis, data not available.

The estimated dose to muscle from cesium-137 was highest in Tampa, Fla., for each of the 3 years under study. This is in agreement with findings of Karches, et al. (*10*). The highest value was in 1966, 3.7 mrem/a, decreasing in 1967 to 2.3 mrem/a. In 1968, the estimated dose to muscle at the Florida sampling station again decreased, to 1.5 mrem/a. All other sampling sites except South Dakota had values of less than 2 mrem/a in 1966; in 1967, less than 1 mrem/a; and in 1968, most decreased again. Estimation of dose to liver from dietary cesium-137 in 1966 was calculated to be 5.3 mrem/a in Florida, and ranged from 3.1 mrem/a in South Dakota to less than 2 mrem/a at other stations.

The estimated dose to bone from cesium-137 in mrem/a was calculated to be 2.7 at Tampa, Fla., the highest value in 1966. All other stations' estimates of dose to bone in 1966 from cesium-137 were <1 mrem/a. As expected, the muscle and bone doses indicated a decreasing trend during the period covered by this study.

REFERENCES

(*1*) ANDERSON, E. C. and D. J. NELSON, JR. Surveillance for radiological contamination in food. Amer J Pub Hlth 52:139 (1962). See also *Radiation Data and Reports* for continuous updating of ITDSN.

(*2*) CAHILL, D. F. and J. K. WHEELER. The biological half-life of cesium-137 in children, determined by urinary assay. Health Phys 14:239 (1968).

(*3*) MOGHISSI, A. A., M. W. CARTER, and R. LIEBERMAN. Radiobioassay Program of the Institutional Total Diet Sampling Network: I. Analytical data related to samples collected during 1966–1968. Radiat Data Rep 14:129–144 (March 1973).

(*4*) MOGHISSI, A. A. and M. G. MAYES. Radiobioassay program of the Institutional Total Diet Sampling Network: II. Selected physiological constants of urine. Radiat Data Rep, this issue.

(*5*) REHNBERG, G. L., C. R. PORTER, and B. KAHN. Estimation of cesium-137 body burden in children. Health Phys (in press).

(*6*) McNEIL, K. G. and O. A. D. TROJAN. The cesium discrimination ratio. Health Phys 4:109 (1960).

(*7*) OBERHAUSEN, E. and C. O. ONSTEAD. Relationship of potassium content of man with age and sex. Radioactivity in Man, G. R. Meneely and S. M. Linde, Editors. Charles C. Thomas, Springfield, Ill. (1965). See also contributions of Remenchick, et al. and Anderson in the same book.

(*8*) ANDERSON, E. C. and W. H. LANGHAM. Average potassium concentration of the human body as a function of age. Science 130:713 (1959).

(*9*) INTERNATIONAL COMMISSION ON RADIATION PROTECTION. Permissible dose for internal radiation, ICRP Report No. 2. Pergamon Press, New York, N.Y. (1959).

(*10*) KARCHES, G. J., J. K. WHEELER, G. L. HEGELSON, and B. KAHN. Cesium-137 body burdens and biological half-life in children in Tampa, Florida, and Lake Bluff, Illinois. Health Phys 16:301 (1969).

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SECTION I. MILK AND FOOD

Milk Surveillance, December 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk

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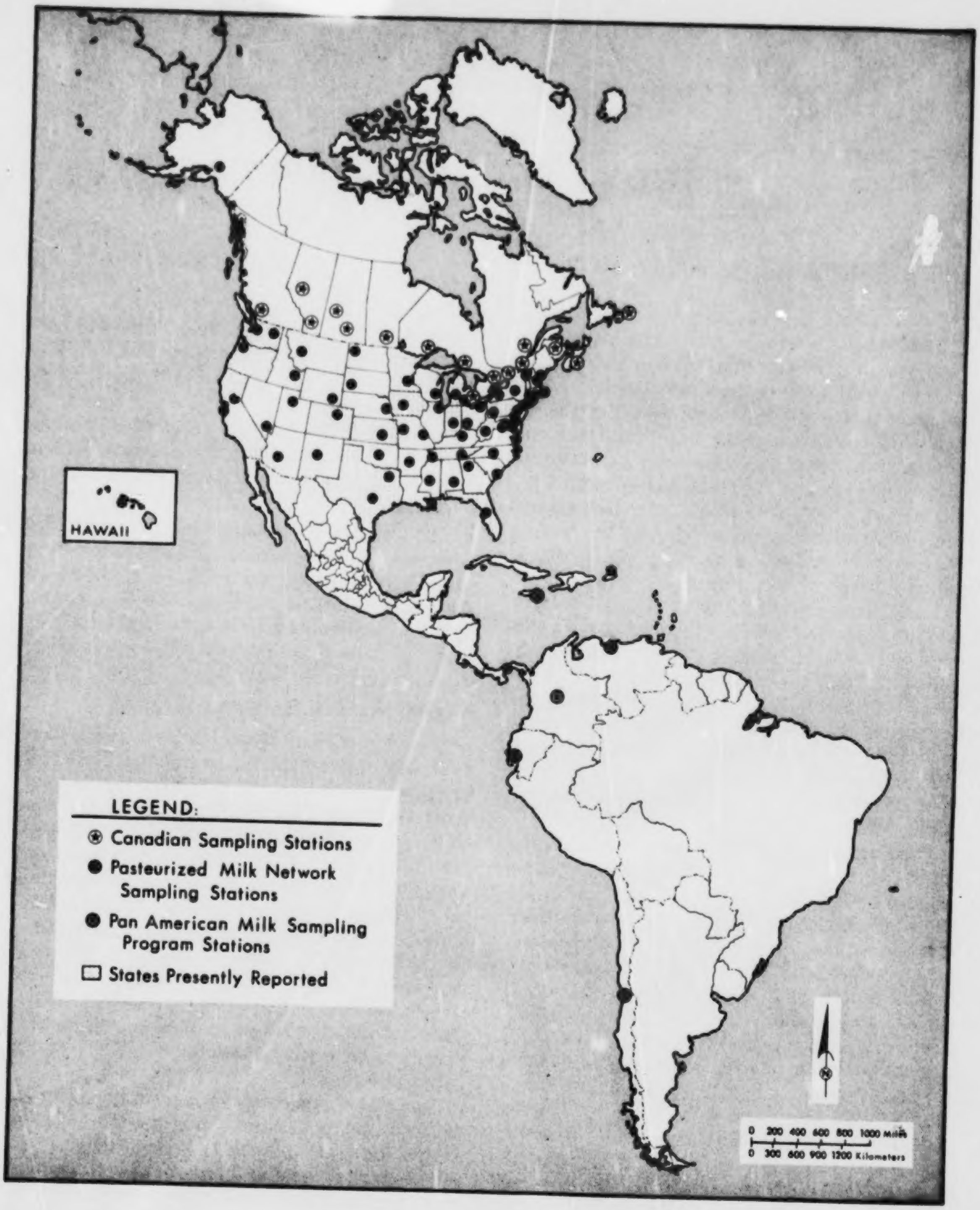
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
● Pan American Milk Sampling Program Stations
☐ States Presently Reported
N
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

1b

have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of the analyses of all radionuclides compared to the results of previous studies. Some improvement is still needed in the technique for determining the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels.

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131 (69 pCi/liter)	13 (100%)	0	0	13	6
Cesium-137 (52 pCi/liter)	12 (92%)	1 (8%)	0	13	6
Strontium-89 (31 pCi/liter)	9 (90%)	1 (10%)	0	10	6
Strontium-90 (41.6 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13	2.4

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milksheds or sampling areas, the differences in concentration of radionuclides in new and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Anaytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≧ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≧ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≧ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports*.

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported in *Radiation Data and Reports*. The relationship between the

Table 2. Concentrations of radionuclides in milk for December 1972 and 12-month period January 1972 through December 1972

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	6	12	6
Alaska:	Palmer[c]	P	5	5	0	6
Ariz:	Phoenix[c]	P	NA	0	0	0
Ark:	Little Rock[c]	P	7	11	0	4
Calif:	Sacramento[c]	P	NA	1	0	0
	San Francisco[c]	P	NA	1	0	0
	Del Norte	P	10	12	0	9
	Fresno	P	0	1	0	4
	Humboldt	P	3	4	0	6
	Los Angeles	P	0	2	0	3
	Mendocino	P	2	5	15	6
	Sacramento	P	0	2	0	5
	San Diego	P	0	1	0	4
	Santa Clara	P	0	1	0	4
	Shasta	P	0	2	0	6
	Sonoma	P	2	2	0	5
Colo:	Denver[c]	P	NA	4	0	3
	East	R	NS	NA	NS	0
	Northeast	R	NS	NA	NS	1
	Northwest	R	NS	NA	NS	0
	South Central	R	NS	NA	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NS	NA	0[d]	0
	West	R	NS	NA	NS	4
Conn:	Hartford[c]	P	NA	5	13	8
	Central	P	6	7	14	13
Del:	Wilmington[c]	P	NA	9	0	8
D.C:	Washington[c]	P	NA	7	0	6
Fla:	Tampa[c]	P	3	5	27	35
	Central	R	6	5	30	41
	North	R	8	6	15	16
	Northeast	R	7	5	51	33
	Southeast	R	5	5	48	53
	Tampa Bay area	P	4	5	34	36
	West	R	10	8	15	15
Ga:	Atlanta[c]	P	NS	9	NS	10
Hawaii:	Honolulu[c]	P	0	2	0	1
Idaho:	Idaho Falls[c]	P	0	4	0	0
Ill:	Chicago[c]	P	5	5	0	9
Ind:	Indianapolis[c]	P	NA	6	0	3
	Central	P	10	7	0	10
	Northeast	P	6	6	10	10
	Northwest	P	8	8	0	10
	Southeast	P	7	8	0	10
	Southwest	P	7	7	10	10
Iowa:	Des Moines[c]	P	NA	4	0	0
	Iowa City	P	4	7	0	7
	Des Moines	P	4	6	0 (3)	5
	Little Cedar	P	7	7	0	8
	Le Mars	P	3	3	0	0
Kans:	Wichita[c]	P	NA	7	0	0
	Coffeyville	P	NA	8	0	9
	Dodge City	P	NA	5	0	7
	Falls City, Nebr	R	NA	3	NS	8
	Hays	P	NA	9	0	7
	Kansas City	P	NA	8	3	9
	Topeka	P	NA	7	0	8
	Wichita	P	NA	8	2	5
Ky:	Louisville[c]	P	NA	7	0	6
La:	New Orleans[c]	P	11	12	0	3
Maine:	Portland[c]	P	NA	6	17	23
Md:	Baltimore[c]	P	NA	7	0	5
Mass:	Boston[c]	P	7	7	14	14
Mich:	Detroit[c]	P	NA	6	0	8
	Grand Rapids[c]	P	NA	8	0	6
	Bay City	P	0	4	0 (2)	8
	Charlevoix	P	5	5	0 (5)	10
	Detroit	P	3	4	0	7
	Grand Rapids	P	3	4	0	7
	Lansing	P	4	4	0 (2)	9
	Marquette	P	5	5	0 (2)	18
	Monroe	P	0	2	0	4
	South Haven	P	6	5	0 (4)	8
Minn:	Minneapolis[c]	P	NA	7	11	16
	Bemidji	P	6	7	10	18
	Duluth	P	15	15	16	27
	Fergus Falls	P	6	7	10	20
	Little Falls	P	14	17	11	39
	Mankato	P	5	5	11	11
	Marshall	P	NS	5	NS	12

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for December 1972 and 12-month period January 1972 through December 1972—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES—Continued						
Minn:	Minneapolis	P	7	10	8	14
	Rochester	P	6	7	8	11
Miss:	Jackson [c]	P	NA	9	0	7
Mo:	Kansas City [c]	P	NA	5	0	1
	St. Louis [c]	P	NA	6	0	3
Mont:	Helena [c]	P	NA	4	0	3
Nebr:	Omaha [c]	P	NA	6	0	1
Nev:	Las Vegas [c]	P	NA	1	0	0
N.H:	Manchester [c]	P	NA	8	11	16
N.J:	Trenton [c]	P	NA	7	15	6
N. Mex:	Albuquerque [c]	P	NA	1	0	0
N.Y:	Buffalo [c]	P	3	5	0	4
	New York City [c]	P	NA	8	0	8
	Syracuse [c]	P	NA	6	0	7
	Albany	P	0	4	0	0
	Buffalo	P	0	6	0	0
	Massena	P	4	8	0	0
	New York City	P	0	7	0	0
	Syracuse	P	0	5	0	0
N.C:	Charlotte [c]	P	NA	9	0	6
N. Dak:	Minot [c]	P	NA	9	0	6
Ohio:	Cincinnati [c]	P	NA	6	0	4
	Cleveland [c]	P	NA	7	0	7
Okla:	Oklahoma City [c]	P	NA	5	0	2
Oreg:	Portland [c]	P	4	5	0	3
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia [c]	P	NA	6	0	3
	Pittsburgh [c]	P	NA	9	15	8
	Dauphin	P	NA		NA	
	Erie	P	NA		NA	
	Philadelphia	P	NA		NA	
	Pittsburgh	P	NA		NA	
R.I:	Providence [c]	P	NA	6	0	9
S.C:	Charleston [c]	P	7	8	0	13
S. Dak:	Rapid City [c]	P	NA	7	0	2
Tenn:	Chattanooga [c]	P	NA	8	0	7
	Memphis [c]	P	NA	7	0	1
	Chattanooga	P	NA	10	0	10
	Clinton	R	NA	10	0	12
	Fayetteville	R	NA	10	6 (2)	6
	Kingston	R	NA	10	8 (2)	7
	Knoxville	P	NA	8	11 (2)	8
	Lawrenceburg	R	NS	1	NS	2
	Nashville	P	NA	8	0	9
	Pulaski	R	NA	7	6 (2)	7
	Sequoyah	R	NS	7	NS	17
Tex:	Austin [c]	P	NA	2	0	0
	Dallas [c]	P	NA	6	0	0
	Amarillo	P	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City [c]	P	3	3	0	3
Vt:	Burlington [c]	P	NA	6	15	12
Va:	Norfolk [c]	P	NA	6	0	7
Wash:	Seattle [c]	P	NA	3	0	2
	Spokane [c]	P	NA	4	0	5
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	1	0	0
	Longview	R	0	4	0	2
	Sandpoint, Idaho	R	5	9	0	10
	Skagit County	R	6	7	0	4
W. Va:	Charleston [c]	P	NA	8	0	5
Wisc:	Milwaukee [c]	P	NS	5	NS	7
Wyo:	Laramie [c]	P	NA	3	0	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for December 1972 and 12-month period January 1972 through December 1972—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:						
Alberta:	Calgary	P	6	6	10	16
	Edmonton	P	6	7	20	25
British Columbia:	Vancouver	P	6	7	11	20
Manitoba:	Winnipeg	P	5	6	13	17
New Brunswick:	Moncton	P	7		7	8
Newfoundland:	St. John's	P	15	19	17	24
Nova Scotia:	Halifax	P	7	8	11	16
Ontario:	Ottawa	P	6	6	11	10
	Sault Ste. Marie	P	10	11	12	22
	Thunder Bay	P	9	10	12	21
	Toronto	P	3	3	10	9
	Windsor	P	3	8	5	7
Quebec:	Montreal	P	6	7	7	11
	Quebec	P	8	9	16	21
Saskatchewan:	Regina	P	5	6	11	13
	Saskatoon	P	7	7	11	13
CENTRAL AND SOUTH AMERICA:						
Canal Zone:	Cristobal [c]	P	NA	1	0	9
Chile:	Santiago	P	0	1	0	1
Colombia:	Bogota	P	2	1	0	0
Ecuador:	Guayaquil	P	0	0	0	0
Jamaica:	Kingston	P	NS	3	NS	45
Puerto Rico:	San Juan [c]	P	NA	1 1	0 0	8
Venezuela:	Caracas	P	0	0	0	0
PMN network average [e]			5	6	2	6

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

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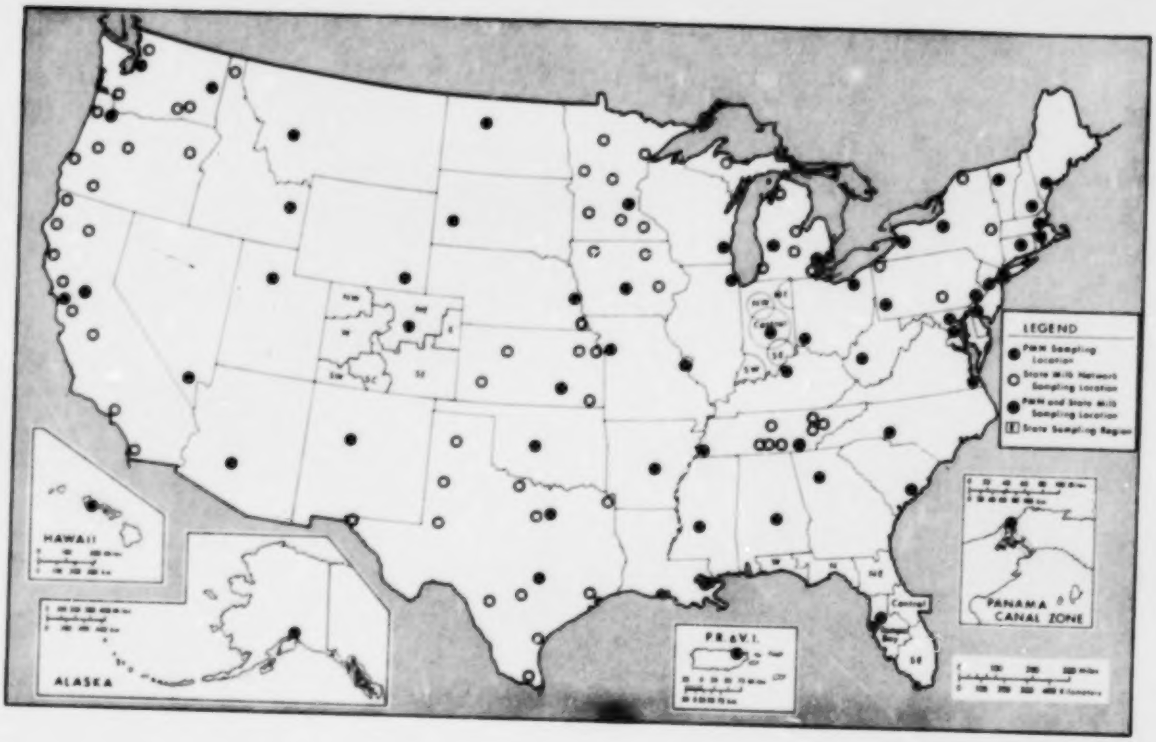
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
State Sampling Region
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE

Figure 2. State and PMN milk sampling stations in the United States

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for December 1972 and the 12-month period, January 1972 to December 1972. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for December 1972 were below the respective practical reporting levels.

Strontium-90 monthly averages ranged from 0 to 15 pCi/liter in the United States for December 1972, and the highest 12-month average was 17 pCi/liter (Little Falls, Minn.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 51 pCi/liter in the United States for December 1972, and the highest 12-month average was 53 pCi/liter (Southeast Florida) representing 1.5 percent of the value derived from the recommendations given in the Federal Radiation Council Report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

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Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Bureau of Radiological Health
Environmental Health & Consumer
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California Department of Public Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
Social and Health Services

REFERENCES

(*1*) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(*4*) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(*5*) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, strontium-89 and strontium-90 measurements in milk, July 1971, Technical experiment 71–MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1971).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(*7*) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Milk Surveillance Programs, October 1972

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 32 regular and 5 alternate sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.

In the event of a release of radioactivity from the NTS, special sampling within the affected

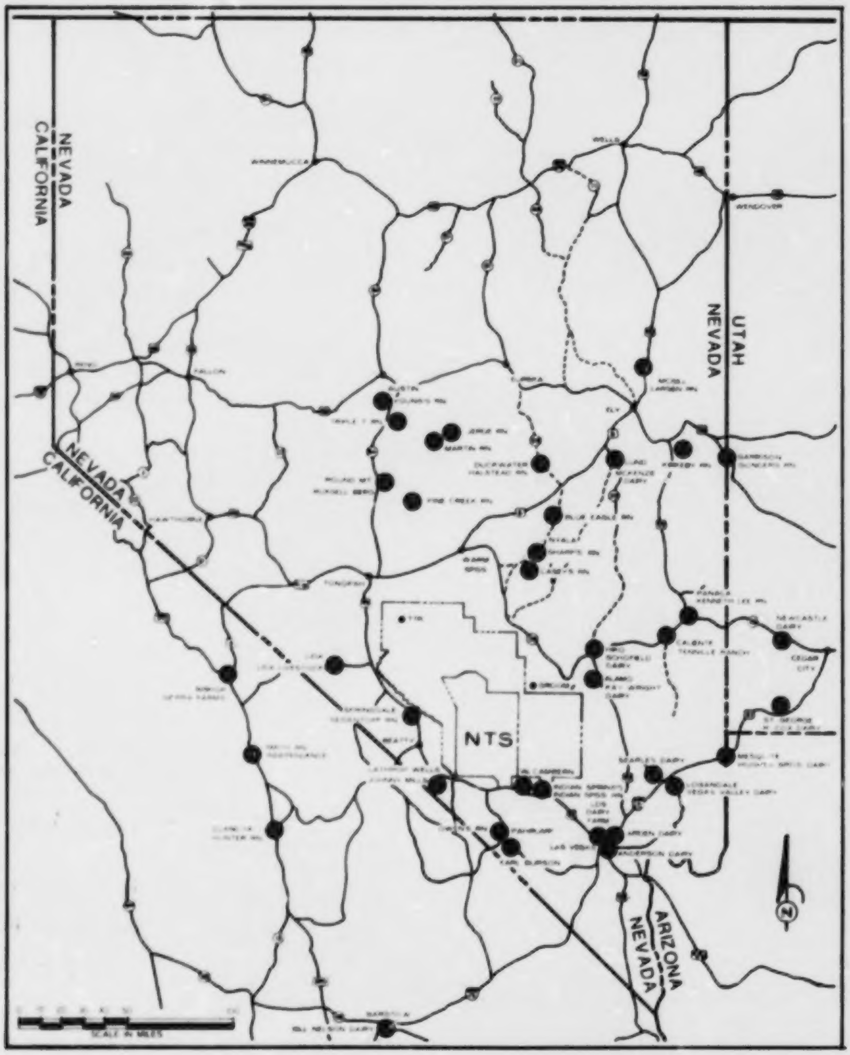

Figure 1. NERC-LV Milk Surveillance Network

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[1] This network is operated under a Memorandum of Understanding (No. AT (26-1)-539) with the Nevada Operations Office, AEC, Las Vegas, Nev.

Table 1. Milk surveillance results, October 1972

Location	Map number	Date collected (October 1972)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
California:							
Bishop:							
Sierra Farms	5	12	11	<10	<3	2±2	NA
Hinkley:							
Bill Nelson Dairy	13	10	12	<10	<2	<1	NA
Independence:							
Smith Ranch [c]	14	12	13	<100	<2	2±1	NA
Nevada:							
Alamo:							
Williams Dairy	1	5	12	<10	<2	4±2	NA
Austin:							
Young's Ranch	3	3	13	<10	<2	5±2	NA
Belmont:							
Pine Creek Ranch [c]	4	2	13	<100	<3	4±2	NA
Currant:							
Blue Eagle Ranch	7	4	13	<10	<2	1±1	NA
Duckwater:							
Halstead Ranch [c]	8	4	13	<100	<2	<1	NA
Eureka:							
Martin Ranch	10	12	13	10	<4	9±3	NA
Hiko:							
Schofield Dairy	12	2	12	<10	<2	<1	<200
Indian Springs:							
Indian Springs Ranch	15	3	13	<10	<2	<1	NA
Las Vegas:							
Anderson Dairy	17	11	11	<10	<2	<1	NA
Arden Dairy	18	11	11	<10	<2	<1	NA
LDS Dairy Farms	19	10	12	<10	<2	1±1	<200
Lathrop Wells:							
Mills Ranch	20	5	13	<10	<2	<1	NA
Lida:							
Lida Livestock Company	21	1	13	<10	<2	<2	NA
Logandale:							
Vegas Valley Dairy	22	2	12	<10	<2	<1	NA
Lund:							
McKenzie Dairy	23	3	12	<10	<2	2±2	<200
McGill:							
Larsen Ranch	24	3	13	<10	<1	<1	NA
Mesquite:							
Hughes Bros. Dairy	25	2	12	<10	<1	<1	<200
Moapa:							
Searles Dairy [c]	26	2	12	<100	<2	<1	NA
Nyala:							
Sharp's Ranch	28	4	13	<10	<2	3±1	<200
Pahrump:							
Owens Ranch	31	3	13	<10	<1	<1	NA
Panaca:							
Kenneth Lee Ranch	33	3	13	<10	<2	3±2	NA
Shoshone:							
Kirkeby Ranch	35	2	13	<10	<2	3±2	NA
Springdale:							
Seidentopf Ranch	36	4	13	<10	<2	<1	NA
Utah:							
Garrison:							
Gonder's Ranch	11	2	13	<10	<3	2±1	NA
Newcastle:							
Newcastle Dairy	27	4	12	<10	<2	3±1	NA
St. George:							
R. Cox Diary	37	2	12	<10	<2	2±1	NA

[a] 11, pasteurized milk.
12, raw milk from Grade A producer(s).
13, raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased minimum detectable activity.
NA, not analyzed.

area is conducted to determine radionuclide concentrations and to take protective action, if required. Additional sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the December 1972 issue of *Radiation Data and Reports.*

Results

The analytical results of all milk samples collected in October 1972 by NERC-LV surveillance programs are listed in table 1. With the exception of cesium-137 at levels near the minimum detectable activity (MDA) of 10 pCi/liter, no gamma-emitting fission products were detected in any of the samples by gamma spectroscopy analysis. Levels of tritium, strontium-89, and strontium-90 near the MDA's for these radionuclides (~ 200 pCi/liter, 2 pCi/liter, and 1 pCi/liter, respectively) were also measured by radiochemistry analyses. Copies of these results were distributed to EPA Regional Offices and appropriate State agencies prior to publication.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1971	December 1972
Carbon-14 in Total Diet and Milk	July–December 1971	May 1972
Connecticut Standard Diet	January–December 1971	December 1972
	This program has been discontinued	
Institutional Total Diet	October–December 1971 and 1971 Annual Summary	June 1972
Radiostrontium in Milk	January–December 1971	November 1972
Strontium-90 in Tri-City Diets	January–December 1971	December 1972

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence [1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January–December 1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January–December 1971	February 1973
Michigan	January–June 1970	November 1971
Minnesota	July 1970–June 1971	November 1972
New York	July–December 1970 and January–June 1971	May 1972
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water	July–December 1971	November 1972
Tritium Surveillance System	July–September 1972	February 1973
Washington	July 1969–June 1970	March 1972
Water Surveillance Programs, *NERC–LV*	July–September 1972	March 1973

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the develoment of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States October-November 1972

Office of Water Planning and Standards
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Planning and Standards. Regional offices of the Environmental Protection Agency are responsible for the collection and retrieval system. Radioactivity analyses was performed in the centralized laboratories of the Office of Water Planning and Standards (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). With the publication of data for January 1971, this activity was resumed as a monthly report series. The unpublished data for the time interval of November 1968 through December 1970 will be the subject of a future summary article.

Tables 1 and 2 present the gross alpha and beta radioactivity results for samples collected from rivers during October and September 1972. The analytical procedures used for determining gross alpha and beta radioactivity are

Table 1. Gross radioactivity in U.S. surface waters, October 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Colorado River:					
Moab, Utah					
Highway bridge	3	2.3 22.1 12.8	10.5 10.3 20.3	9 50 61	20 18 56
Above Mill Creek, Utah	3	3.0 5.2 16.9	10.8 11.1 20.0	10 17 49	13 27 44
Dolores River:					
Bedrock, Colo	2	7.1 18.4	18.3 4.4	16 123	25 15
Gateway, Colo	2	18.3 6.2	47.7 24.5	33 19	67 39
Green River:					
Greendale, Utah	2	.3	3.5	<1	11
LaBarge, Wyo		<.3	.6	<1	5
Ohio River:					
Cincinnati, Ohio	2	.7 .4	<1.0 <.9	<1 <1	6 6
Roanoke River:					
John Kerr Dam, Va	1	.3	<.6	1	4
San Miguel River:					
Uravan, Colo	2	1.5 7.0	5.5 4.3	5 24	16 8
Below Uravan, Colo	2	5.5 15.6	27.3 7.8	13 32	23 10
Naturita, Colo	2	<.3 .4	4.3 1.6	2 2	7 4
San Juan River:					
Bluff, Ariz	1	17.0	3.2	43	11
St. Lawrence River:					
Massena, N.Y	4	<.3 <.4 <.3 <.3	<.6 <.5 <.5 <.5	<1 <1 <1 <1	5 9 5 5

Table 2. Gross radioactivity in U.S. surface waters, November 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Roanoke River: John Kerr Dam, Va	3	<0.3 <.3 <.3	<0.3 <.3 <.4	<1 <1 <1	2 2 2
St. Lawrence River: Massena, N.Y	3	<.3 <.3 <.3	<.5 <.6 <.6	<1 <1 <1	4 5 6
Susquehanna River: Holtwood, Pa	1	<.4	<1.1	1	4

described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are collected for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivty, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Water Surveillance Programs, October 1972

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Water Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 90 sampling locations (figures 1 and 2) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.

In the event of a release of radioactivity from the NTS, special sampling within the

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, AEC, Las Vegas, Nev.

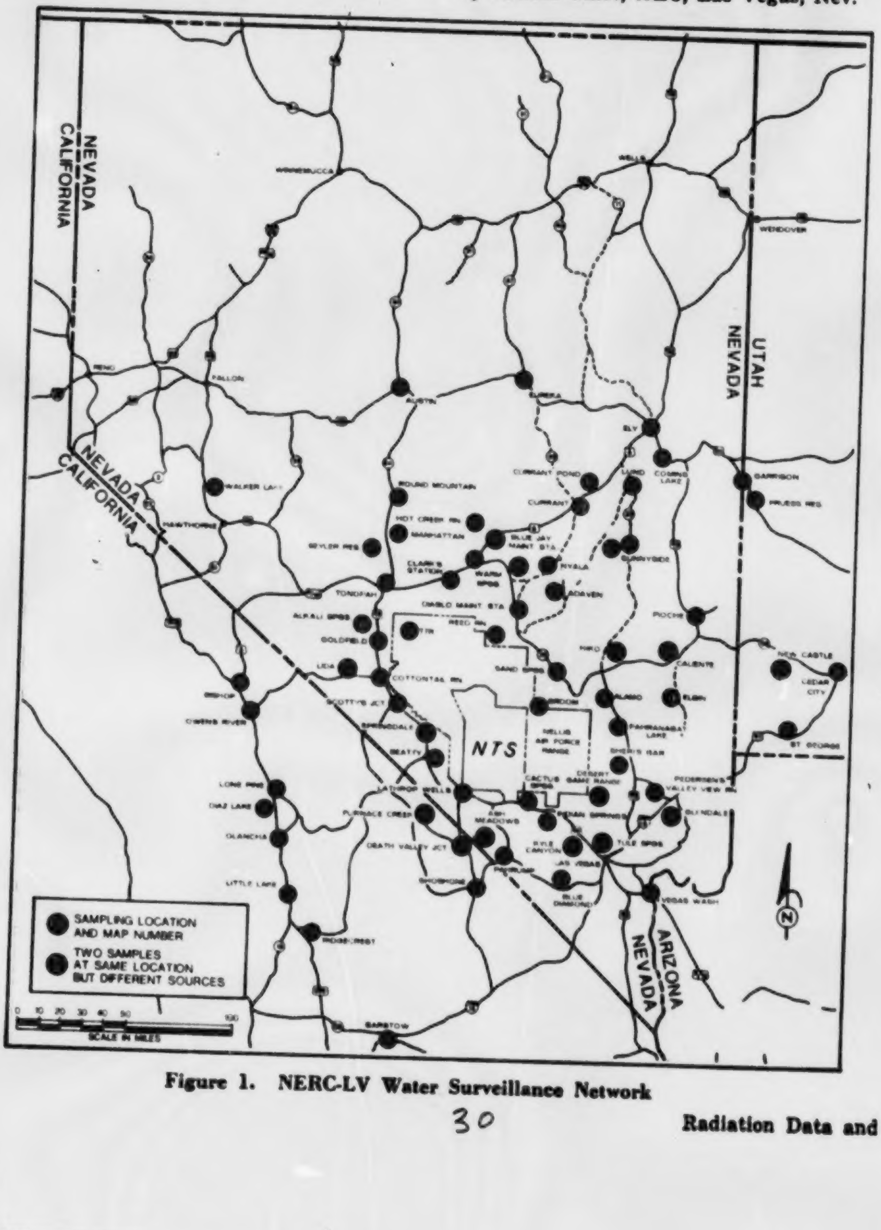
NEVADA
CALIFORNIA
WINNEMUCCA
WELLS
WENDOVER
UTAH
NEVADA
RENO
FALLON
AUSTIN
EUREKA
ELY
WALKER LAKE
HAWTHORNE
ROUND MOUNTAIN
HOT CREEK RN
MANHATTAN
SEYLER RES
CURRANT POND
CURRANT
LUND
COMINS LAKE
GARRISON
PRUESS RES
BLUE JAY MAINT STA
NYALA
SUNNYSIDE
CLARK'S STATION
WARM SPGS
ADAVEN
TONOPAH
DIABLO MAINT STA
ALKALI SPGS
GOLDFIELD
TTR
REED RN
PIOCHE
HIKO
CALIENTE
NEW CASTLE
CEDAR CITY
LIDA
COTTONTAIL RN
SAND SPGS
ALAMO
ELGIN
BISHOP
OWENS RIVER
SCOTTY'S JCT
SPRINGDALE
PAHRANAGAT LAKE
ST GEORGE
NTS
NELLIS AIR FORCE RANGE
BEATTY
DESERT GAME RANGE
CACTUS SPGS
PEDERSEN'S VALLEY VIEW RN
LONE PINE
DIAZ LAKE
LATHROP WELLS
FURNACE CREEK
ASH MEADOWS
INDIAN SPRINGS
GLENDALE
OLANCHA
DEATH VALLEY JCT
KYLE CANYON
TULE SPGS
LAS VEGAS
PAHRUMP
SHOSHONE
BLUE DIAMOND
VEGAS WASH
LITTLE LAKE
RIDGECREST
BARSTOW
ARIZONA
NEVADA
N
SAMPLING LOCATION AND MAP NUMBER
TWO SAMPLES AT SAME LOCATION BUT DIFFERENT SOURCES
0 10 20 30 40 50 100
SCALE IN MILES

Figure 1. NERC-LV Water Surveillance Network

30

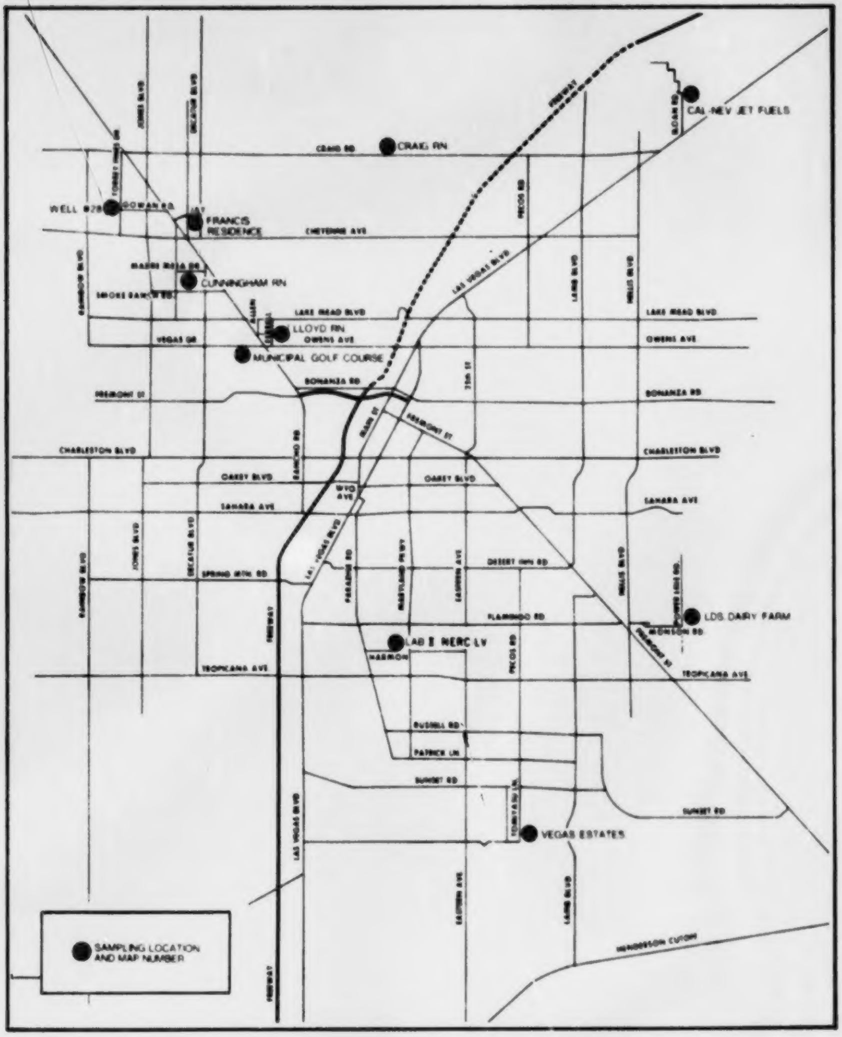
FREEWAY
CAL-NEV JET FUELS
SLOAN RD
CRAIG RD
CRAIG RN
JONES BLVD
DECATUR BLVD
WELL #28
GOWAN RD
FRANCIS RESIDENCE
CHEYENNE AVE
PECOS RD
LAS VEGAS BLVD
LAMB BLVD
NELLIS BLVD
RAINBOW BLVD
CUNNINGHAM RN
LAKE MEAD BLVD
LLOYD RN
VEGAS DR
OWENS AVE
MUNICIPAL GOLF COURSE
BONANZA RD
FREMONT ST
25th ST
MAIN ST
CHARLESTON BLVD
RANCHO RD
OAKEY BLVD
WYO AVE
SAHARA AVE
SPRING MTN RD
PARADISE RD
MARYLAND PKWY
EASTERN AVE
DESERT INN RD
FLAMINGO RD
LDS DAIRY FARM
MONSON RD
LAB I NERC LV
HARMON
TROPICANA AVE
RUSSELL RD
PATRICK LN
SUNSET RD
VEGAS ESTATES
HENDERSON CUTOFF
SAMPLING LOCATION AND MAP NUMBER

Figure 2. Water Surveillance Network—Las Vegas Valley

affected area is conducted to determine radionuclide concentrations and to take protective action, if required. Other sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and routine analytical procedures was included with the water results reported in the November 1972 issue of *Radiation Data and Reports*.

Results

The analytical results of all water samples collected in October 1972 by the NERC–LV Water Surveillance Network are listed in table 1. No gamma-emitting fission products were detected in any of the samples by gamma spectroscopy analysis. The analytical results of samples selected for special analyses will be reported at a later date.

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Table 1. NERC-LV water surveillance results, October 1972

Location	Map number	Data collected (1972)	Sample type [b]	Radioactivity concentration [a] (pCi/liter)		
				Gross alpha	Gross beta	Tritium
California:						
Bishop:						
Fish and Game Office	9	12	23	<2.3	<3.7	NA
Owens River, 3 miles east	10	11	22	<3.9	<4.0	NA
Death Valley Junction:						
Lila's Cafe	21	13	23	8 ±7	9 ±5	230 ±220
Furnace Creek:						
Pond	28	13	21	<7.3	7 ±3	NA
Visitor's Center	29	13	27	<5.4	12 ±4.5	NA
Hinkley:						
Bill Nelson Diary	39	10	23	<6.5	8 ±4	NA
Little Lake:						
Little Lake Ranch	60	11	21	10 ±7.9	23 ±5.2	NA
Lone Pine:						
Diaz Lake	61	11	21	21 ±9.4	27 ±5.3	NA
Forest Service Ranger Station	62	11	23	<3.0	7 ±4	NA
Olancha:						
Halwee Reservoir	73	11	21	<3.6	4 ±4	NA
Ridgecrest:						
City Hall	76	11	23	<5.0	<4.0	NA
Shoshone:						
Chevron Service Station	79	13	27	<6.9	23 ±5.1	NA
Nevada:						
Adaven:						
Canfield Ranch	1	4	22	10 ±5	8 ±4	NA
Alamo:						
Sheri's Bar	2	2	23	<3.4	<3.3	NA
Pahranagat Lake	3	2	21	22 ±8.6	37 ±5.1	NA
Williams Dairy	4	2	23	5 ±5	12 ±3.9	NA
Ash Meadows:						
Ash Meadows Lodge	5	10	23	<8.4	19 ±4.2	<230
Ash Meadows Pond	6	10	21	12 ±8.6	17 ±4.1	NA
Austin:						
County Courthouse	7	4	27	20 ±6.3	18 ±4.0	NA
Beatty:						
Richfield Service Station	8	5	23	12 ±9.4	16 ±4.1	<220
Blue Diamond:						
Post Office	11	2	23	<5.6	<3.1	<230
Blue Jay Highway:						
Maintenance Station	12	4	23	9 ±5	5 ±3	NA
Cactus Springs:						
Mobile Service Station	13	3	27	<3.6	<3.1	<220
Caliente:						
Agricultural Extension Station	14	4	22	9 ±5	5 ±3	NA
Meadow Valley Wash	15	4	22	<6.6	14 ±3.9	NA
Clark Station:						
Five Mile Ranch	17	4	27	<3.4	5 ±3	NA
Coyote Summit:						
Sand Spring Well	18	3	23	37 ±10	26 ±4.6	NA
Currant:						
Currant Pond	19	4	21	<4.4	6 ±3	NA
Currant Ranch Cafe	20	3	27	16 ±7.1	7 ±3	NA
Diablo Highway:						
Maintenance Station	22	4	23	4 ±3	8 ±3	NA
Diablo:						
Reed Ranch	23	3	21	24 ±8.7	44 ±5.4	NA
Elgin:						
Water Tower	24	4	23	<6.0	8 ±3	NA
Ely:						
Chevron Service Station	25	2	24	<3.5	3 ±3	NA
Comins Lake	26	2	21	<7.8	52 ±5.7	NA
Eureka:						
Chevron Service Station	27	4	24	<4.5	5 ±3	NA
Glendale:						
Chevron Service Station	32	2	27	8 ±7	15 ±3.9	NA
Muddy River	33	2	22	11 ±7.4	13 ±4.1	NA
Goldfield:						
Alkali Springs	34	2	21	<12	6 ±4	NA
Chevron Service Station	35	2	23	<5.8	<3.2	NA
Hawthorne:						
Walker Lake [c]	36					
Hiko:						
Crystal Springs	37	2	27	7 ±4	5 ±3	NA
Schofield Dairy	38	2	23	30 ±9.1	29 ±4.8	NA
Indian Springs:						
Chevron Service Station	40	3	23	7 ±5	5 ±3	<230
Las Vegas:						
Cal-Nev Jet Fuels	41	10	23	<4.4	<3.1	<220
Craig Ranch Golf Course	42	10	23	8 ±5	5 ±3	<220
Cunningham Ranch	43	10	23	<4.1	<3.1	<220
Desert Game Range	44	3	23	<4.1	<3.1	270 ±220
Desert Game Range Pond	45	3	21	<3.9	<3.1	<220
Francis Residence	46	10	23	<6.9	4 ±3	<220
Lab II, NERC-LV	47	10	24	<4.6	7 ±4	930 ±230

See footnotes at end of table.

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Table 1. NERC-LV water surveillance results, October 1972—Continued

Location	Map number	Data collected (1972)	Sample type [b]	Radioactivity concentration [a] (pCi/liter) Gross alpha	Gross beta	Tritium
Nevada:						
Lake Mead Vegas Wash	48	10	21	<7.4	6 ±3	890 ±230
LDS Dairy Farm	49	10	23	<11	13 ±4.1	<220
Lloyd Ranch	50	10	23	<7.1	6 ±3	<220
L V Water District Well 28	51	10	23	<4.1	<3.1	<230
Municipal Golf Course	52	10	23	<4.2	5 ±3	<220
Tule Springs	53	3	23	<4.0	<3.1	<220
Tule Springs Pond	54	3	21	<3.6	6 ±3	NA
Vegas Estates	55	10	23	<7.7	10 ±4	<220
Lathrop Wells: Texaco Service Station	56	4	23	<5.5	4 ±3	<220
Lida Junction: Cottontail Ranch	57	2	23	<6.5	12 ±3.8	NA
Lida: Lida Livestock Company	58	2	27	9 ±6	<3.1	NA
Pond at storage tank	59	2	21	<4.8	<3.1	NA
Lund: Gardner Grocery	63	3	23	<5.0	5 ±3	NA
Manhattan: Country Store	64	4	23	11 ±7.1	7 ±3	NA
Seyler Reservoir	65	4	21	5.4	18 ±4.1	NA
Mercury: Groom Lake	66	3	23	4 ±3	4 ±3	NA
Moapa: Pedersen Valley View Ranch	67	2	27	8 ±5	7 ±4	NA
Mt. Charleston: Kyle Canyon Fire Station	68	3	27	<4.2	<3.1	240 ±230
Nyala: Sharp's Ranch	72	4	23	<3.1	<3.2	NA
Pahrump: Texaco Service Station	74	2	23	<4.2	<3.1	NA
Pioche: County Courthouse	75	3	24	<4.0	7 ±3	NA
Round Mt: Mobil Service Station	77	4	27	<3.4	<3.1	NA
Scotty's Junction: Chevron Service Station	78	2	23	<7.4	8 ±4	<220
Springdale: Peacock Ranch	80	4	27	<6.4	6 ±3	<220
Pond	81	4	21	<7.2	14 ±3.9	NA
Sunnyside: Adam McGill Reservoir	83	3	21	9 ±6	7 ±3	NA
Wildlife Management Headquarters	84	3	27	<3.8	4 ±3	NA
Tonopah: Jerry's Chevron Station	85	3	23	<4.5	7 ±3	NA
Tonopah Test Range CP-1	86	3	23	<5.4	6 ±3	NA
Warm Springs: Fallini's Pond	87	4	21	42 ±15	100 ±8.0	NA
Hot Creek Ranch	88	4	27	<4.8	11 ±3.8	NA
Service Station and Cafe	89	3	27	32 ±11	39 ±5.3	NA
Twin Springs Ranch	90	4	23	8 ±5	10 ±3.7	NA
Utah:						
Cedar City: M. D. Baldwin Reservoir	16	3	24	<2.6	<3.3	NA
Garrison: Pruess Reservoir [c]	30					
Rowley Grocery	31	2	23	<4.4	3 ±3	NA
Newcastle: Municipal Reservoir	70	3	21	<4.3	7 ±4	NA
Newcastle Dairy	71	4	24	<4.3	7 ±4	NA
St. George: R. Cox Dairy	82	2	24	<2.1	<3.2	NA

[a] Two-sigma counting error provided when available.

[b] 21—pond, lake, reservoir, stock tank, stock pond.
22—stream, river, creek.
23—well.
24—Multiple supply—mixed water sample consisting of mixed or multiple sources of water, such as well or spring.
27—spring.

[c] Quarterly samples.
NA, not analyzed.

For the purpose of identifying the source of gross radioactivity in all network samples and comparing concentrations with both the AEC Concentration Guides and the PHS Drinking Water Standards, selected samples are being given special analyses at least once a year beginning with samples taken during calendar year 1972. For surface water samples, the special analyses will include strontium-89, strontium-90, plutonium-238, plutonium-239, uranium, and radium-226.

Copies of these results are distributed to EPA Regional Offices and appropriate State agencies prior to publication.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports*.

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January–December 1970	December 1971
Mexican air monitoring program	May–August 1972	January 1973
Plutonium in airborne particulates	July–September 1972	March 1973
Surface air sampling program, 80th Meridian Network, *HASL*	January–December 1969	February 1972

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1. Radiation Alert Network
December 1972

Quality Assurance and
Environmental Monitoring Laboratory
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Quality Assurance and Environmental Monitoring Laboratory, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during December 1972.

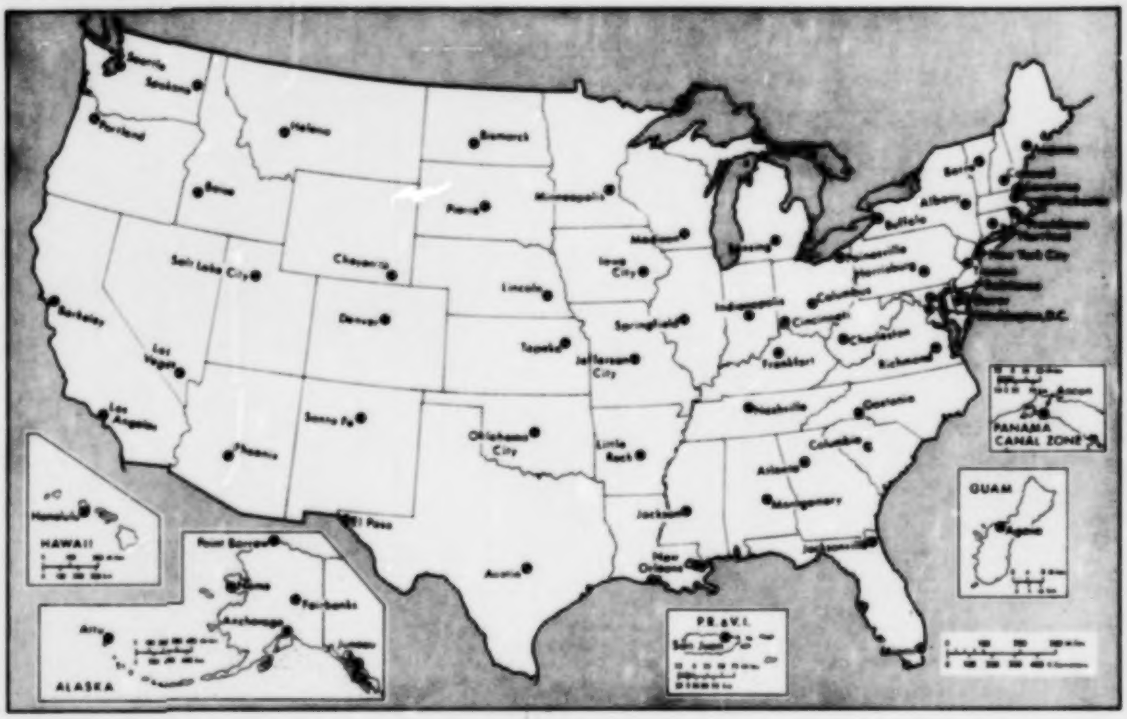
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Buffalo
Albany
Barre
Augusta
Harrisburg
Cheyenne
Salt Lake City
Iowa City
Lincoln
Indianapolis
Columbus
Cincinnati
Denver
Springfield
Berkeley
Las Vegas
Topeka
Jefferson City
Frankfort
Charleston
Richmond
New York City
Los Angeles
Santa Fe
Oklahoma City
Nashville
Little Rock
Columbia
Phoenix
Atlanta
Montgomery
Jackson
El Paso
New Orleans
Austin
Jacksonville
HAWAII
Honolulu
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
ALASKA
P.R. & V.I.
San Juan
PANAMA CANAL ZONE
Ancon
GUAM
Agana

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, December 1972

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
			Maximum	Minimum	Average [a]	Number of samples	Total depth (mm)	Field estimation of deposition: Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	18	2	0	0	3	107	3	107	12
Alaska:	Anchorage	2	8	0	0	0				
	Attu Island	31	8	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	17	12	0	3	0				
Ark:	Little Rock	4	0	0	0	0				
Calif:	Berkeley	19	1	0	0	5	58	5	58	0
	Los Angeles	19	2	0	1	0				
C.Z:	Ancon	14	0	0	0	0				
Colo:	Denver	17	1	0	0	2	26	(b)		
Conn:	Hartford	18	0	0	0	9	143	9	143	0
Del:	Dover	16	0	0	0	0				
D.C:	Washington	12	0	0	0	0				
Fla:	Jacksonville	16	1	0	0	6	105	6	105	2
	Miami	0				0				
Ga:	Atlanta	3	1	0	0	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	18	1	0	0	0		(b)		
Idaho:	Boise	18	3	0	0	3	56	3	56	0
Ill:	Springfield	3	0	0	0	0				
Ind:	Indianapolis	18	1	0	0	0				
Iowa:	Iowa City	19	1	0	1	3	41	3	41	3
Kans:	Topeka	19	2	0	0	3	19	3	19	0
Ky:	Frankfort	11	1	0	0	0				
La:	New Orleans	17	1	0	0	6	150	(b)		
Maine:	Augusta	19	0	0	0	11	116	11	116	0
Md:	Baltimore	20	1	0	0	9	73	9	73	0
Mass:	Lawrence	20	0	0	0	7	126	7	126	0
	Winchester	17	1	0	0	7	155	7	155	0
Mich:	Lansing	19	0	0	0	0				
Minn:	Minneapolis	20	2	0	1	5	9	5	9	3
Miss:	Jackson	12	1	0	0	5	221	5	221	0
Mo:	Jefferson City	16	1	0	0	5	10	5	10	0
Mont:	Helena	15	1	0	0	0				
Nebr:	Lincoln	18	3	0	1	2	15	2	15	1
Nev:	Las Vegas	18	5	0	3	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	1	0	0	12	144	12	144	4
N. Mex:	Santa Fe	13	1	0	0	0				
N.Y:	Albany	18	2	0	1	0				
	Buffalo	20	0	0	0	0				
	New York City	0				0				
N.C:	Gastonia	17	4	1	1	3	51	(b)		
N. Dak:	Bismarck	19	2	0	1	3	6	3	6	1
Ohio:	Cincinnati	0				0				
	Columbus	2	0	0	0	0				
	Painesville	19	0	0	0	10	72	10	72	21
Okla:	Oklahoma City	3	2	0	1	0				
Oreg:	Portland	20	0	0	0	8	184	8	184	10
Pa:	Harrisburg	19	1	0	0	1	15	1	15	2
P.R:	San Juan	0				0				
R.I:	Providence	15	0	0	0	0				
S.C:	Columbia	8	1	0	1	4	128	4	128	2
S. Dak:	Pierre	14	2	1	1	0				
Tenn:	Nashville	15	1	0	0	9	145	9	145	13
Tex:	Austin	13	7	1	2	2	29	(b)		
	El Paso	19	5	1	2	0				
Utah:	Salt Lake City	27	1	0	0	8	24	8	24	4
Vt:	Barre	19	0	0	0	9	96	9	96	9
Va:	Richmond	19	0	0	0	4	216	4	216	40
Wash:	Seattle	9	0	0	0	6	141	(b)		
	Spokane	18	1	0	0	0				
W. Va:	Charleston	17	1	0	0	12	120	12	120	12
Wisc:	Madison	17	0	0	0	6	34	6	34	2
Wyo:	Cheyenne	11	1	0	0	0				
Network summary		914	12	0	1	188	105	6	90	5

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

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2. Canadian Air and Precipitation Monitoring Program,[1] December 1972

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for December 1972 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, December 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.0	0.0	0.0	28	1.0
Coral Harbour	1	.0	.0	.0	159	.2
Edmonton	4	.0	.0	.0	9	.3
Ft. Churchill	4	.0	.0	.0	19	.1
Fredericton	4	.0	.0	.0	5	1.0
Goose Bay	4	.0	.0	.0	10	.5
Halifax	4	.0	.0	.0	4	.8
Inuvik	4	.0	.0	.0	8	.3
Montreal	4	.0	.0	.0	7	1.0
Moosonee	4	.0	.0	.0	7	.2
Ottawa	3	.0	.0	.0	4	.5
Quebec	4	.0	.0	.0	3	.4
Regina	4	.1	.0	.0	31	.4
Resolute	4	.0	.0	.0	64	.1
St. John's, Nfld	4	.0	.0	.0	10	1.2
Saskatoon	3	.0	.0	.0	9	.2
Sault Ste. Marie	4	.1	.0	.0	12	1.0
Thunder Bay	4	.0	.0	.0	8	.3
Toronto	4	.0	.0	.0	4	.5
Vancouver	4	.0	.0	.0	4	1.1
Whitehorse	4	.0	.0	.0	10	.3
Windsor	NS				3	.8
Winnipeg	4	.0	.0	.0	16	.4
Yellowknife	1	.0	.0	.0	20	.2
Network summary	84	0.1	0.0	0.0	19	0.5

NS, no sample.

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

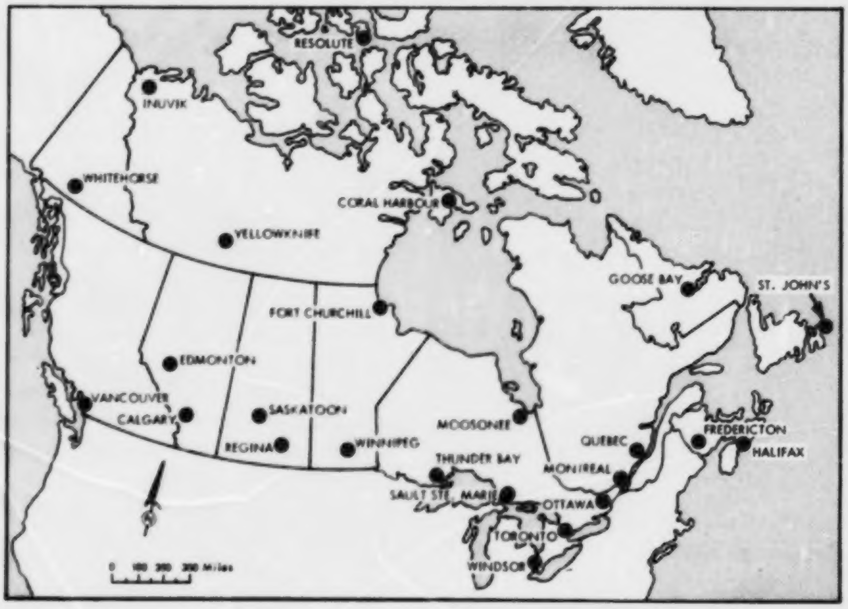
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
0 100 200 300 Miles

Figure 2. Canadian air and precipitation monitoring program

37

3. Pan American Air Sampling Program December 1972

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The December 1972 air monitoring results from the participating countries are given in table 3.

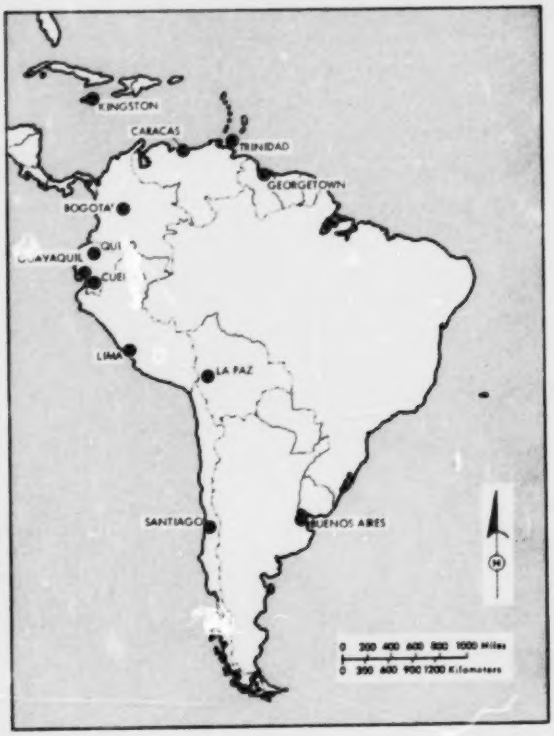

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, December 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	14	0.03	0.00	0.01
Chile:	Santiago	27	.06	.01	.03
Colombia:	Bogota	18	.02	.00	.01
Ecuador:	Cuenca	0			
	Guayaquil	18	.04	.01	.02
	Quito	9	.00	.00	.00
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	0			
West Indies:	Trinidad	15	.03	.00	.01
Pan American summary		101	0.06	0.00	0.02

[a] The monthly average is calculated by weighting the individual samp with length of sampling period. Values less than 0.005 pCi/m³ are reporte and used in averaging as 0.00 pCi/m³.

4. California Air Sampling Program December 1972

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where the [illegible] analyzed for their radioactive content.

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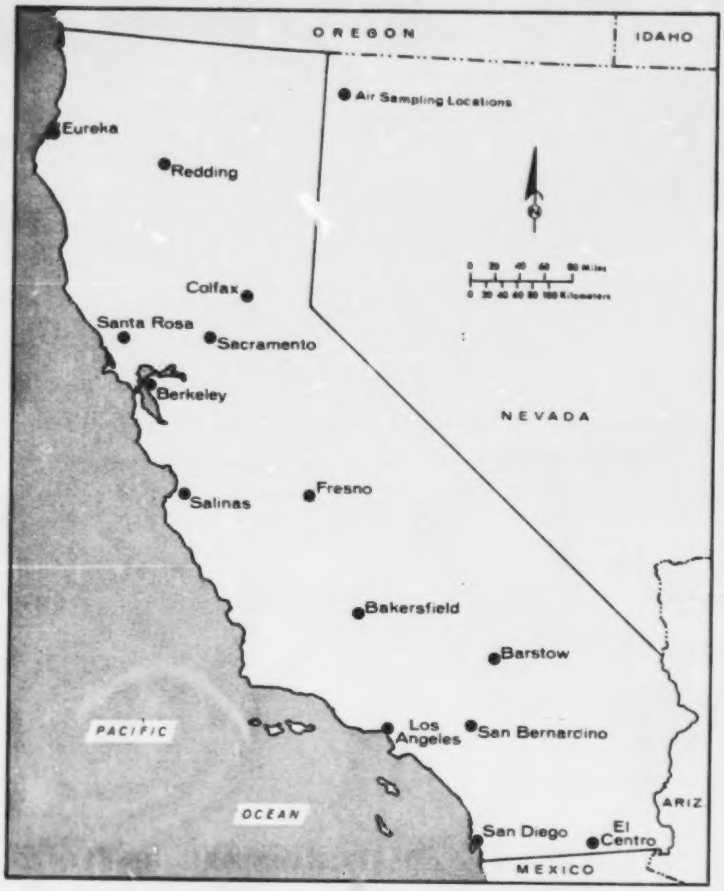
OREGON
IDAHO
Air Sampling Locations
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
PACIFIC
OCEAN
Los Angeles
San Bernardino
ARIZ
San Diego
El Centro
MEXICO
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers

Figure 4. California air sampling program stations

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity, in air for December 1972. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air December 1972

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Bakersfield	17	1.10	0.03	0.16
Barstow	21	.72	.02	.23
Berkeley	31	.22	.00	.07
Colfax	31	.07	.00	.04
El Centro	29	1.09	.04	.17
Eureka	20	.05	.00	.02
Fresno	29	.51	.03	.10
Los Angeles	29	.26	.00	.09
Redding	28	.08	.01	.04
Sacramento	29	.16	.00	.07
Salinas	29	1.35	.00	.21
San Bernardino	27	.82	.00	.15
San Diego	29	.42	.00	.10
Santa Rosa	30	.17	.00	.06
Summary	379	1.35	0.00	0.11

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

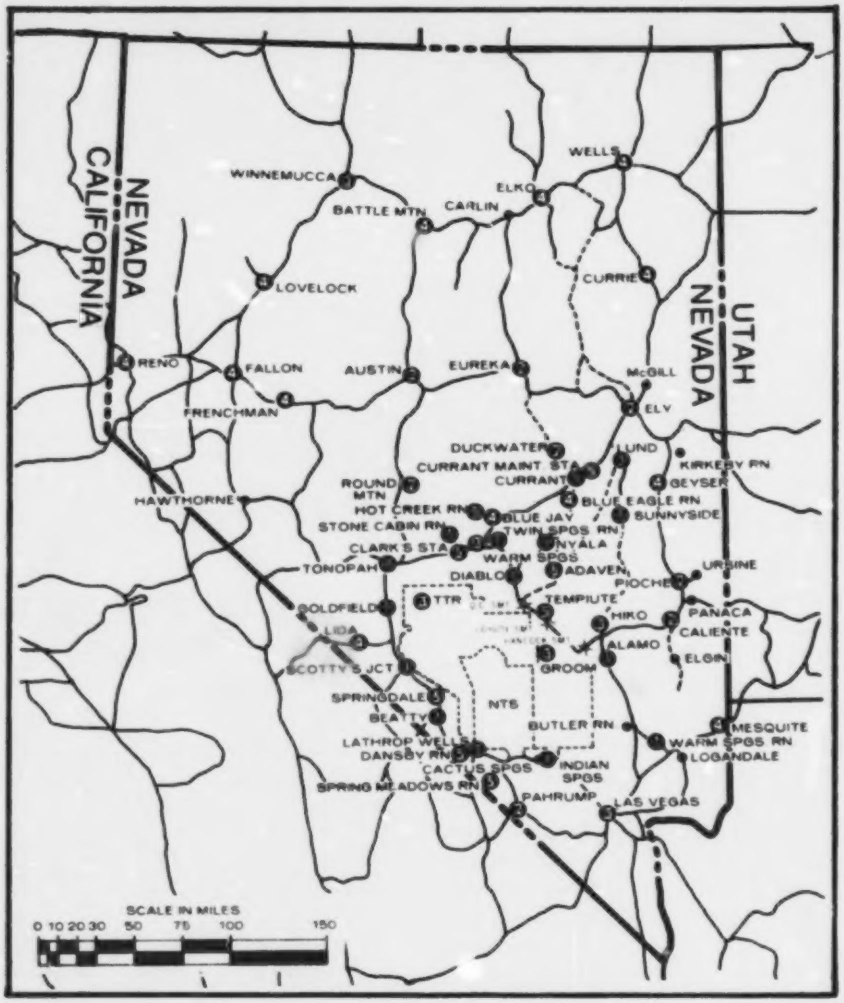
NEVADA
CALIFORNIA
UTAH
NEVADA
WINNEMUCCA
WELLS
ELKO
CARLIN
BATTLE MTN
LOVELOCK
CURRIE
RENO
FALLON
AUSTIN
EUREKA
McGILL
ELY
FRENCHMAN
DUCKWATER
LUND
KIRKEBY RN
CURRANT MAINT. STA.
CURRANT
GEYSER
ROUND MTN
BLUE EAGLE RN
HAWTHORNE
HOT CREEK RN
BLUE JAY
SUNNYSIDE
STONE CABIN RN
TWIN SPGS. RN
NYALA
CLARK'S STA
WARM SPGS
TONOPAH
DIABLO
ADAVEN
URSINE
PIOCHE
GOLDFIELD
TTR
TEMPIUTE
HIKO
PANACA
CALIENTE
LIDA
ALAMO
GROOM
ELGIN
SCOTTY'S JCT
SPRINGDALE
NTS
BEATTY
BUTLER RN
MESQUITE
LATHROP WELLS
WARM SPGS RN
DANSBY RN
LOGANDALE
CACTUS SPGS
INDIAN SPGS
SPRING MEADOWS RN
PAHRUMP
LAS VEGAS
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. NERC-LV Air Surveillance Network stations in Nevada

Air Surveillance Network, December 1972

National Environmental Research Center—Las Vegas,[1] Environmental Protection Agency

The Air Surveillance Network[2] (ASN), operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station (which lies within the NTS), and by the AEC at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in February 1972 issue of *Radiation Data and Reports.*

Results

Table 1 presents the monthly average gross

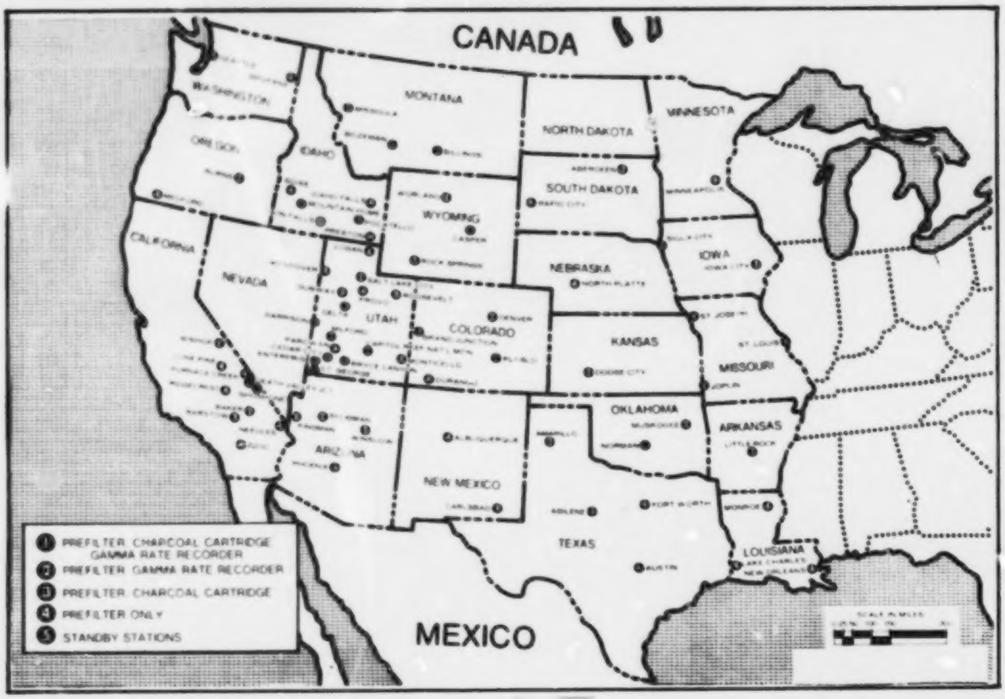
CANADA
MEXICO
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
DENVER
CASPER
ROCK SPRINGS
GRAND JUNCTION
PUEBLO
DURANGO
SALT LAKE CITY
NORTH PLATTE
DODGE CITY
IOWA CITY
ST. LOUIS
LITTLE ROCK
NORMAN
ALBUQUERQUE
CARLSBAD
FORT WORTH
AUSTIN
LAKE CHARLES
NEW ORLEANS
1 PREFILTER CHARCOAL CARTRIDGE GAMMA RATE RECORDER
2 PREFILTER GAMMA RATE RECORDER
3 PREFILTER CHARCOAL CARTRIDGE
4 PREFILTER ONLY
5 STANDBY STATIONS
SCALE IN MILES

Figure 2. NERC-LV Air Surveillance Network stations outside Nevada

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[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

Table 1. Summary of gross beta radioactivity concentrations in air, December 1972

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average [a]
Ariz:	Kingman	31	<0.1	<0.1	0.1
	Phoenix	30	.1	<.1	.1
	Seligman	31	<.1	<.1	.1
	Winslow	31	.1	<.1	.1
Ark:	Little Rock	10	.1	<.1	.1
Calif:	Baker	25	.2	<.1	.1
	Barstow	30	.1	<.1	.1
	Bishop	30	.1	<.1	.1
	Death Valley Junction	31	<.2	<.1	.1
	Furnace Creek	31	.1	<.1	.1
	Indio	30	.1	<.1	.1
	Lone Pine	29	.1	<.1	.1
	Needles	24	.2	<.1	.1
	Ridgecrest	31	.1	<.1	.1
	Shoshone	31	.1	<.1	.1
Colo:	Denver	19	.1	<.1	.1
	Durango	31	.1	<.1	.1
Idaho:	Boise	27	.2	<.1	.1
	Idaho Falls	21	.1	<.1	.1
	Preston	30	.2	<.1	.1
	Twin Falls	30	<.1	<.1	.1
Iowa:	Iowa City	18	.1	<.1	.1
	Sioux City	24	.1	<.1	.1
Kans:	Dodge City	31	<.1	<.1	.1
La:	Lake Charles	20	.1	<.1	.1
	Monroe	17	.1	<.1	.1
	New Orleans	18	<.1	<.1	.1
Minn:	Minneapolis	20	.1	<.1	.1
Mo:	Joplin	31	<.1	<.1	.1
	St. Joseph	31	1.0	<.1	.1
	St. Louis	30	.1	<.1	.1
Nebr:	North Platte	24	.1	<.1	.1
Nev:	Alamo	30	.1	<.1	.1
	Austin	12	<.1	<.1	.1
	Battle Mountain	30	.1	<.1	.1
	Beatty	31	.1	<.1	.1
	Blue Eagle Ranch (Currant)	30	.2	<.1	.1
	Blue Jay	31	.1	<.1	.1
	Caliente	31	.3	.1	.1
	Currant	8	<.1	<.1	.1
	Currant Ranch	32	<.6	<.1	.1
	Currie	5	<.1	<.1	.1
	Diablo	31	.2	<.1	.1
	Duckwater	29	.2	<.1	.1
	Elko	31	.1	<.1	.1
	Ely	31	<.1	<.1	.1
	Eureka	31	<.1	<.1	.1
	Fallini's Twin Springs Ranch	31	.1	<.1	.1
	Fallon	31	.1	<.1	.1
	Frenchman Station	31	.3	<.1	.1
	Geyser Maintenance Station	30	<.1	<.1	.1
	Goldfield	30	.1	<.1	.1
	Groom Lake	19	.1	<.1	.1
	Hiko	31	.1	<.1	.1
	Indian Springs	31	<.1	<.1	.1
	Las Vegas	18	.1	<.1	.1
	Lathrop Wells	29	.1	<.1	.1
	Lida	31	<.1	<.1	.1
	Lovelock	31	.1	<.1	.1
	Lund	18	<.1	<.1	.1
	Mesquite	31	.1	<.1	.1
	Nyala	31	.2	<.1	.1
	Pahrump	15	<.1	<.1	.1
	Pioche	30	<.1	<.1	.1
	Reno	31	.1	<.1	.1
	Round Mountain	31	<.5	<.1	.1
	Scotty's Junction	30	<.1	<.1	.1
	Stone Cabin Ranch	31	.1	<.1	.1
	Sunnyside	22	.1	<.1	.1
	Tonopah	31	.1	<.1	.1
	Tonopah Test Range	23	<.1	<.1	.1
	Warm Springs	31	.1	<.1	.1
	Warm Springs Ranch	31	.1	<.1	.1
	Wells	31	<.1	<.1	.1
	Winnemucca	31	.1	<.1	.1
N. Mex:	Albuquerque	19	<.4	<.1	.1
	Carlsbad	27	.2	<.1	.1
Okla:	Muskogee	29	<.1	<.1	.1
Oreg:	Burns	27	.1	<.1	.1
	Medford	23	<.1	<.1	.1
S. Dak:	Aberdeen	31	<.1	<.1	.1
	Rapid City	30	.1	<.1	.1
Tex:	Abilene	26	.2	<.1	.1
	Amarillo	31	.1	<.1	.1
	Austin	16	.1	<.1	.1
	Fort Worth	30	<.1	<.1	.1

See footnote at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air, December 1972—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average [a]
Utah:	Bryce Canyon	22	<.1	<.1	.1
	Cedar City	31	<.2	<.1	.1
	Delta	31	.2	<.1	.1
	Dugway	31	.2	<.1	.1
	Enterprise	31	<.1	<.1	.1
	Garrison	31	<.1	<.1	.1
	Logan	30	.2	<.1	.1
	Milford	30	<.2	<.1	.1
	Monticello	31	<.1	<.1	.1
	Parowan	28	.2	<.1	.1
	Provo	31	.1	<.1	.1
	Roosevelt	31	.5	<.1	.2
	Salt Lake City	30	.1	<.1	.1
	St. George	31	<.2	<.1	.1
	Wendover	9	<.1	<.1	.1
Wash:	Seattle	20	<.1	<.1	.1
	Spokane	19	.1	<.1	.1
Wyo:	Rock Springs	29	<.1	<.1	.1
	Worland	31	.2	<.1	.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1.

beta concentrations in air for each of the network stations. The highest gross beta concentrations within the network was 1.0 pCi/m³ at St. Joseph, Mo. The minimum reporting concentration for gross beta is 0.1 pCi/m³. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06 pCi/m³) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reporting level (0.1 pCi/m³) are reported as <0.1 pCi/m³. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during December.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC–LV upon written request.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follow for Rocky Flats Plant.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Rocky Flats Plant[2]
January–December 1970

Dow Chemical Company
Golden, Colo.

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission (AEC). Its location, relative to population centers, is shown in figure 1. The basic goal guiding these operations is total containment of radioactive materials. The environmental survey program is designed to assure that radioactive materials released are below the AEC standards. Following a fire in a plutonium production building on May 11, 1969, environmental monitoring was enhanced, including expanded plutonium analyses of air, water, vegetation, and soil samples as well as gross alpha analyses (uranium plus plutonium) routinely performed.

The plant is located about 15 miles northwest of Denver, Colo. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

Air

Air samples, representative of 10 minutes of each hour, were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner Station, Golden, Denver, and Westminster. Samples are collected weekly and analyzed for total long-lived alpha radioactivity. The monthly average gross alpha radioactivity is shown in table 1. The recommended AEC concentration guide for insoluble plutonium is 1 pCi/m^3 averaged over 1 year for the individual in the general population. The measured activity in table 1 ranges from 2 to 29 fCi/m^3 for January to June and 1 to 9 fCi/m^3 for July to December and is indistinguishable from

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[2] Summarized from "Environmental Survey, January–June, July–December 1970", The Dow Chemical Company, Rocky Flats Division, Golden, Colo.

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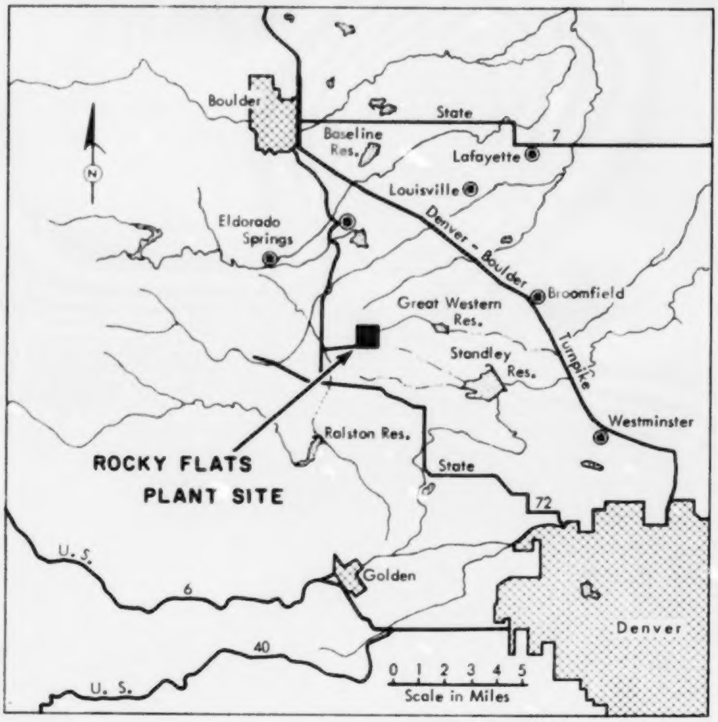
Boulder
State
7
Baseline Res.
Lafayette
Louisville
Denver - Boulder Turnpike
Eldorado Springs
Broomfield
Great Western Res.
Standley Res.
Westminster
Ralston Res.
ROCKY FLATS PLANT SITE
State
72
U. S.
6
Golden
Denver
40
U. S.
0 1 2 3 4 5
Scale in Miles
N

Figure 1. Location of Rocky Flats Plant

Table 1. Gross long-lived alpha (uranium + plutonium) in offsite air samples. RFP environs, January–December 1970

Location	Average concentration (fCi/m³)					
	January	February	March	April	May	June
Boulder	8	11	10	10	9	8
Broomfield	4	9	9	14	7	6
Coal Creek	8	9	11	9	5	6
Denver	10	9	11	9	6	9
Golden	11	15	13	16	6	9
Lafayette	9	11	11	13	11	6
Marshall	12	9	12	23	23	5
Wagner Station	5	3	4	10	7	7
Westminster	9	11	16	29	6	2

	July	August	September	October	November	December
Boulder	6.0	7.1	7.9	5.8	4.9	4.9
Broomfield	5.6	7.3	6.0	6.0	4.1	2.7
Coal Creek	5.6	5.1	4.3	4.3	4.7	3.1
Denver	5.1	5.4	4.7	4.7	4.5	3.9
Golden	6.0	5.6	5.1	6.0	4.1	5.5
Lafayette	6.0	5.8	8.1	4.7	4.7	5.7
Marshall	5.6	8.6	5.6	5.5	4.8	4.6
Wagner Station	4.7	5.1	5.6	6.4	5.0	1.1
Westminster	4.9	5.4	4.9	6.0	5.5	5.6

levels of activity resulting from naturally-occurring long-lived alpha emitters. The fluctuations in the range are statistical variations due to the low levels of activity being measured.

Water

Four reservoirs in the area are sampled biweekly. Local community tap water samples are collected monthly. A small pond on Walnut Creek at Indiana Street (Rocky Flats effluent course) is sampled weekly. Other streams and lakes in the area are sampled twice a year. These samples are analyzed for gross alpha radioactivity content (uranium plus plutonium) and for plutonium by alpha spectrometry. Tables 2 and 3 summarize the results of the water sampling program. For January–June 1970 the results indicate a gross alpha range of <0.1 to 11 pCi/liter in the reservoirs and Walnut Creek sampling program and <0.1 to 13 pCi/liter from the community tap water supplies. The radioactivity of the Ralston Reservoir samples (11 pCi/liter) and the Arvada tap water sample (13 pCi/liter) has been identified in both cases as >99 percent uranium. The AEC guide for natural uranium is 20,000 pCi/liter. Maximum plutonium concentration noted was

Table 2. Radioactivity in reservoir samples, RFP environs, January–December 1970

Reservoir	Number of samples	Gross alpha radioactivity (plutonium + uranium) (pCi/liter)		Number of samples	Plutonium radioactivity (pCi/liter)	
		Range	Average		Range	Average
January–June 1970						
Baseline	10	<0.1- 0.5	<0.2	6	<0.02-0.14	<0.05
Great Western	11	.1- .8	.2	8	<.02- .23	<.10
Ralston	11	.8-11	3.1	8	<.02- .80	<.17
Standley	9	.1- .6	.4	8	<.02- .10	<.07
Walnut Creek	19	.2- 4.5	1.7	16	<.02-1.45	<.62
July–December 1970						
Baseline	13	0.18 - 9.00	2.77	9	<0.004 -1.53	<0.14
Great Western	13	.13 -9.40	1.96	9	<.004 - .43	<.08
Ralston	13	.50 -65.0	19.1	8	<.004 - .06	<.02
Standley	13	.80 -10.10	3.7	9	<.004 - .21	<.08
Walnut Creek	26	<.005-40.19	<5.49	22	<.0004-5.64	<.75

Table 3. Radioactivity in community tap water, RFP environs, January–December 1970

Station	Number of samples	Gross alpha radioactivity (plutonium + uranium) (pCi/liter)		Number of samples	Plutonium radioactivity (pCi/liter)	
		Range	Average		Range	Averge
January–June 1970						
Arvada	10	0.5-12.7	2.86	7	<0.02-0.36	<0.11
Boulder	10	<.1- .6	<.2	7	<.02- .06	<.03
Broomfield	8	<.1- .6	<.2	4	<.02- .10	<.06
Denver	9	.1- 2.0	1.2	8	<.02- .29	<.10
Golden	10	<.1- .7	<.4	7	<.02- .12	<.07
Lafayette	9	<.1- 3.5	<.5	5	<.02- .91	<.22
Louisville	9	<.1- 1.4	<.4	7	<.02- .32	<.10
Thornton	10	.2- 3.9	1.7	8	<.02- .16	<.06
Westminster	9	<.1- .7	<.2	5	<.02- .11	<.05
July–December 1970						
Avada	13	0.09 -17.65	3.23	10	<0.0004-0.62	<0.12
Boulder	13	<.005-11.28	<1.39	2	<.0004- .06	<.03
Broomfield	13	<.005- 4.57	<2.36	9	<.0004- .58	<.08
Denver	13	<.005-17.78	<3.65	10	<.0004- .16	<.04
Golden	13	.07 - 7.11	2.09	6	<.0004- .21	<.06
Lafayette	13	.05 -10.27	2.13	5	<.0004- .59	<.22
Louisville	13	<.005-13.72	<1.61	4	<.0004- .19	<.07
Thornton	13	.42 - 7.38	3.01	11	<.0004-1.64	<.21
Westminster	13	<.005- 3.46	<.76	5	<.0004- .07	<.02

1.45 pCi/liter in a sample taken from Walnut Creek at Indiana Street.

The July–December 1970 results indicate a gross alpha concentration range of <0.005 to 65 pCi/liter in the reservoirs and <0.005 to 18 pCi/liter for the community tap water supplies. The 65 pCi/liter activity in Ralston Reservoir and the 18 pCi/liter level in the Denver tapwater were identified as natural uranium. Maximum plutonium concentration noted was 5.64 pCi/liter in a sample taken from Walnut Creek at Indiana Street.

Fallout

Fallout collection trays are located at all offsite air sampling stations and at standby stations located in Arvada, Eastlake and Superior and analyzed for plutonium. More recently, fallout samples from Berthoud and Castle Rock, Colo. also have been collected and analyzed for plutonium. The reported values include fallout resulting from atmospheric atomic test programs as well as that originating from operations at Rocky Flats. Table 4 summarizes the measurements for the January–December 1970 period.

Table 4. Plutonium radioactivity in fallout, RFP environs, January–December 1970

Location	Number of days measured	Average plutonium radioactivity (pCi/m²-month)[a]
January-June 1970		
Arvada	154	5.00
Boulder	127	6.59
Broomfield	154	4.98
Coal Creek	95	5.93
Denver	154	5.88
Eastlake	143	4.27
Golden	154	4.11
Lafayette	154	4.93
Marshall	140	8.24
Superior	154	3.69
Wagner Station	154	10.0
Westminster	126	7.63
July–December 1970		
Arvada	167	9.20
Berthoud	97	<.50
Boulder	153	29.94
Broomfield	153	21.08
Castle Rock	100	<.50
Coal Creek	154	6.75
Denver	181	5.99
Eastlake	153	8.94
Golden	167	19.83
Lafayette	167	3.33
Marshall	167	6.14
Superior	181	9.84
Wagner Station	178	15.02
Westminster	146	10.58

[a] This includes worldwide fallout.

Vegetation

Vegetation samples have been collected semiannually. These samples are analyzed for gross alpha content only. Samples collected from 63 locations during the July–December period were analyzed with activity levels ranging from <0.003 to 0.670 pCi/g dry weight. These results are comparable in activity levels to previous environmental surveys conducted at Rocky Flats. Results for July–December 1970 are summarized in table 5.

Table 5. Gross alpha radioactivity in vegetation samples RFP environs, July–December 1970

Distance from plant	Number of samples	Gross alpha radioactivity (pCi/g dry weight)	
		Range	Average
<5 miles	42	0.003–0.666	0.096
>5 miles	21	.003– .526	.106

Soil

Twenty-three offsite soil samples have been analyzed for plutonium during January–June 1970. These were taken from unsampled locations 2 to 5 miles from the plant. These results are compared with 1969 results in table 6 and show no differences.

Table 6. Plutonium content of offsite soil samples 1969, 1970

Date	Distance from plant	Number of samples	Radioactivity (dpm/g)	
			Range	Average
1969	5 miles or less	48	[a] 0.4–6.7	1.4
1970	2 to 5 miles	23	[b] .1–6.7	1.4

[a] Rocky Flats Lake road at South Boulder Diversion Canal.
[b] Highway 93, ¼-mile south of plant access road.

Table 7 summarizes strontium-90 and plutonium concentrations made on 1969 soil samples. Comparison of plutonium to strontium-90 ratios at various locations might afford an interpolation of the origin of the plutonium in the soil; however, the wide range of strontium-90 concentrations found make any ratio comparison meaningless. No subsequent strontium-90 analyses are planned.

In the July–December period, soil samples were collected within a radius of approximately

Table 7. Plutonium to strontium-90 ratios in soil samples (1969 collection)

Number of samples	Distance from plant	Disintegrations/minute/gram			Plutonium to strontium-90 ratio
		Radioactivity (dpm/g)	Plutonium	Strontium-90	
10	1 mile	Average	1.9	3.55	0.54
		Range	1.2-3.9	0.25-15.9	0.02-11.0
19	2 miles	Average	1.5	3.96	.49
		Range	.2-6.7	.04-30.9	.02-22.3
16	5 miles	Average	1.0	13.2	.08
		Range	.1-3.3	.17-60.0	.01- 6.5

20 miles from the Rocky Flats Plant and were analyzed for plutonium. Samples collected during this period are awaiting analysis.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-December 1969	October 1972

Reported Nuclear Detonations, March 1973

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission conducted an underground nuclear test at its Nevada Test Site on March 8, 1973. The test was in the low-intermediate yield range of 20 to 200 kilotons.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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★U.S. GOVERNMENT PRINTING OFFICE: 1973 — 514-847/9

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIOBIOASSAY PROGRAM OF THE INSTITUTIONAL TOTAL DIET SAMPLING NETWORK II. SELECTED PHYSIOLOGICAL CONSTANTS OF URINE. *A. A. Moghissi* and *Mary G. Mayes. Radiation Data and Reports*, Vol. 14, April 1973, pp. 225–232.

The Institutional Total Diet Sampling Network program, initiated in 1961, has provided information on the intake of certain radionuclides by selected groups of children and young adults, and the resulting radiation dose. Starting with 1966, this was supplemented by a radiobioassay program with the aim of improving radiation dose estimates by using excretion data. Numerous physiological parameters were measured to evaluate their suitability for the validation of a 24-hour urine sample.

The results of measurements of volume, specific gravity, pH value, osmolality, and creatinine in samples collected during 1966–1968 are summarized. Results of these measurements, along with a review of available data, with particular emphasis on creatinine, are presented and discussed.

KEYWORDS: Body burden, children, creatinine, diet, excretion, radiobioassay.

RADIOBIOASSAY PROGRAM OF THE INSTITUTIONAL TOTAL DIET SAMPLING NETWORK III. CESIUM-137 DOSE ESTIMATES AND BODY BURDENS OF CHILDREN. *A. A. Moghissi* and *Mary G. Mayes. Radiation Data and Reports*, Vol. 14, April 1973, pp. 233–236.

Urine samples collected from 10 stations of the Institutional Total Diet Sampling Network program were analyzed. Cesium-137 and potassium in food and urine were analyzed by gamma spectroscopy. The cesium-137 body burdens were established by using content of urine and the biological half-life of cesium in children, and by a model based on intake.

Differences among results obtained, using each of these techniques, are discussed. Radiation dose calculations are based on recommendations in International Commission on Radiation Protection Report Number 2.

KEYWORDS: Body burdens, cesium-137, children, diet, excretion, potassium, radiobioassay.

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RADIATION DATA AND REPORTS

Volume 14, Number 5, May 1973

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Robert W. Fri, Acting Administrator

Tritium Burdens in Two Arctic Villages

John A. Eckert and Roy B. Evans [1]

During a routine visit to measure cesium-137 burdens in residents of two Alaskan villages, drinking water and urine samples were collected and subsequently analyzed for tritium by the National Environmental Research Center-Las Vegas. The mean concentrations at Noatak, Alaska, were 1,200 pCi/liter and 1,500 pCi/liter for tritium in drinking water and urine, respectively. At Kiana, the mean tritium concentration in drinking water was <400 pCi/liter, and the mean tritium concentration in urine was 1,000 pCi/liter.

The National Environmental Research Center, Las Vegas, Nev., has conducted a surveillance program to measure cesium-137 burdens in Alaskan natives since 1968 (*1*). During a routine visit to measure cesium-137 burdens in village residents, urine samples were collected and subsequently analyzed for tritium concentrations. Single urine samples were collected from nine residents of Noatak, Alaska, and 10 residents of Kiana, Alaska, on May 10, 1972 and May 9, 1972, respectively. Figure 1 shows the location of the two Arctic villages. A drinking water sample also was collected in each village.

Sample collection

Urine samples were collected only from residents not wearing luminous dial wrist watches. This precaution was taken to avoid collecting samples from individuals with abnormally high tritium burdens caused by leakage of tritiated luminous compounds found in such watches (*2*). Samples were collected in 1-liter disposable plastic containers to which 1 ml of a 10 percent solution of merthiolate was added as a preservative.

Analytical procedure

Samples were returned to the National Environmental Research Center-Las Vegas for tritium analysis. The samples were then thermally distilled and added to a dioxane-base liquid scintillation cocktail and subsequently counted by liquid scintillation (*3*). Counting times were long enough to insure a detection limit of 400 pCi/liter.

Results

Table 1 lists the analytical results and the age and sex of the subjects residing in Noatak, Alaska. Figure 2 is a log-normal probability plot of tritium concentrations observed in the urine samples collected in Noatak. The mean concentration was 1,500 pCi/liter. For com-

Table 1. Tritium concentrations in the urine of Noatak residents, May 10, 1972

Sex	Age	Tritium concentration (pCi/liter)
F	10	1,300
F	11	2,300
F	12	1,000
M	14	1,600
M	14	1,300
M	15	1,000
M	23	1,900
M	23	1,600
F	31	1,500
		$\bar{x} = 1{,}500$

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[1] National Environmental Research Center—Las Vegas, Environmental Protection Agency, Las Vegas, Nev.

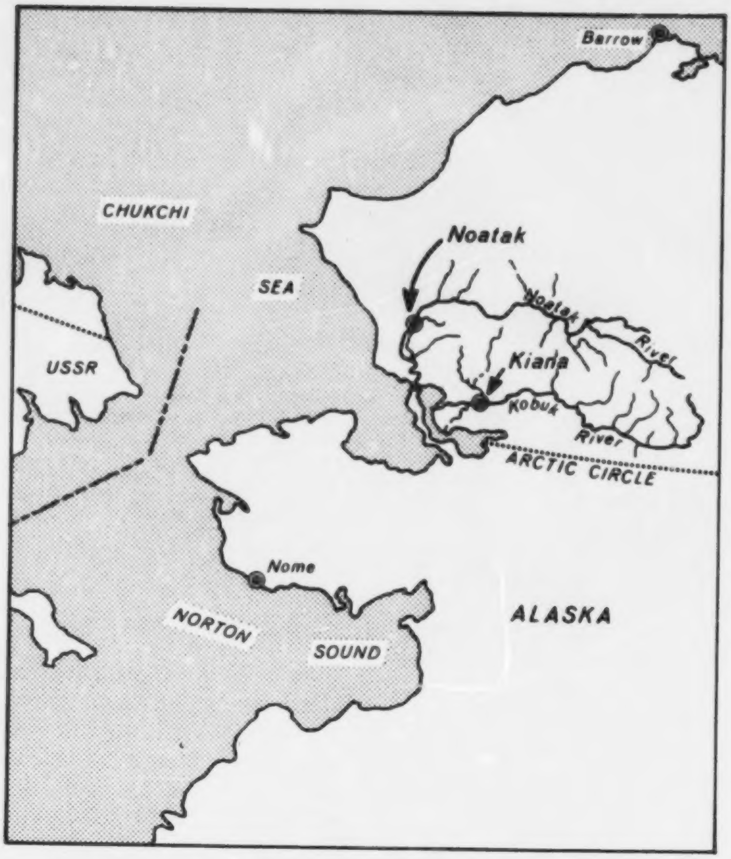
Barrow
CHUKCHI
SEA
Noatak
Noatak River
Kiana
Kobuk River
USSR
ARCTIC CIRCLE
Nome
NORTON
SOUND
ALASKA

Figure 1. Location of two villages where samples were obtained

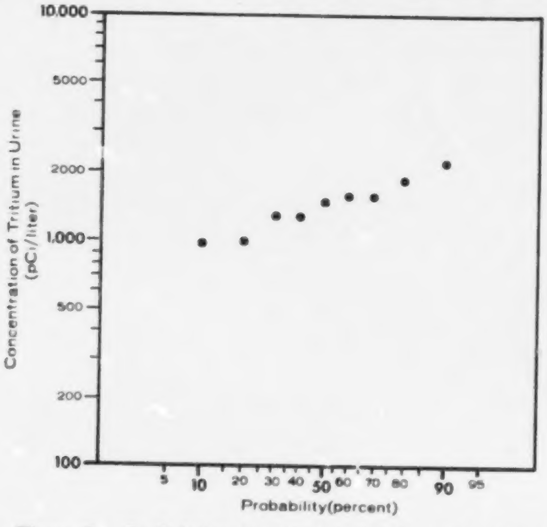

Figure 2. Probability distribution of tritium in urine of Noatak residents for May 1972

parison, the tritium concentration in the sample of village drinking water was 1,200 pCi/liter.

Analytical results, age, and sex of the subjects residing in Kiana, Alaska, are shown in table 2. Figure 3 is a log-normal probability plot of tritium concentrations observed in urine samples collected in Kiana. The mean concentration was 1,000 pCi/liter. The tritium concentration in the drinking water sample from Kiana was found to have a value of less than 400 pCi/liter, significantly lower than the mean value for urine concentration.

Table 2. Tritium concentrations in the urine of Kiana residents, May 9, 1972

Sex	Age	Tritium concentration (pCi/liter)
F	11	1,400
F	11	1,100
M	11	1,500
M	13	600
M	38	1,000
M	42	1,000
F	45	1,100
M	65	1,000
F	67	900
F	74	700
		$\bar{x} = 1{,}000$

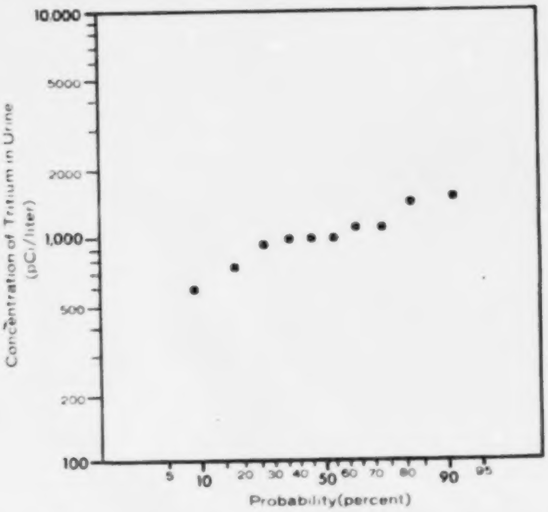

Figure 3. Probability distribution of tritium in urine of Kiana residents for May 1972

Discussion

Estimated annual doses are computed using the conversion factor (*4*):

$$DE = 0.1\ C$$

where,

DE = dose equivalent in mrem/a;
C = concentration of tritium in the body in nCi/liter

The mean urine tritium concentration for Kiana corresponds to an annual dose of 0.1 mrem. The mean tritium concentration for Noatak corresponds to an annual dose of 0.15 mrem. These values are orders of magnitude less than the applicable Federal Radiation Council Radiation Protection Guides (170 mrem/year whole-body dose from nonmedical man-made sources for a suitable sample of the general population) (*5*).

In a study conducted in South Carolina, Moghissi and Lieberman (*6*) observed a ratio between the tritium concentration in drinking water and the tritium concentration in urine of 1:0.4. Moghissi and Lieberman further concluded that the computation of doses based on drinking water tritium concentrations would lead to conservative estimates. This was not the case for the two Arctic villages. The ratio between the tritium concentration in drinking water and the concentration in urine was 1:1.25 for Noatak. The concentration in drinking water for Kiana was below the sensitivity of the analytical technique and the possibility that the result is anomalous will be investigated in subsequent sampling.

REFERENCES

(*1*) ECKERT, J. A., J. S. COOGAN, R. L. MIKKELSEN, and P. N. LEM. Cesium-137 concentrations in Eskimos, spring 1968. Radiol Health Data Rep 11:219–225 (May 1970).

(*2*) FITZSIMMONS, C. K., D. N. McNELIS, and D. T. WRUBLE. Tritium activity in urine from luminous dial wrist watches. Health Phys 22:514–516 (1972).

(*3*) MOGHISSI, A. A., H. L. KELLEY, J. E. REGNIER, and M. W. CARTER. Low-level counting by liquid scintillation. I. Tritium Measurements in Homogeneous Systems. Intnl J Appl Radio-Isotp 20: 145 (1969).

(*4*) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters of the United States, 1966. Radiol Health Data Rep 9:337–339 (July 1968).

(*5*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards. Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*6*) MOGHISSI, A. A. and R. LIEBERMAN. Comparison between tritium concentration in drinking water and body water. Health Phys 22:509–511 (1972).

SECTION I. MILK AND FOOD

Milk Surveillance, January 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmenal releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency) — 5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

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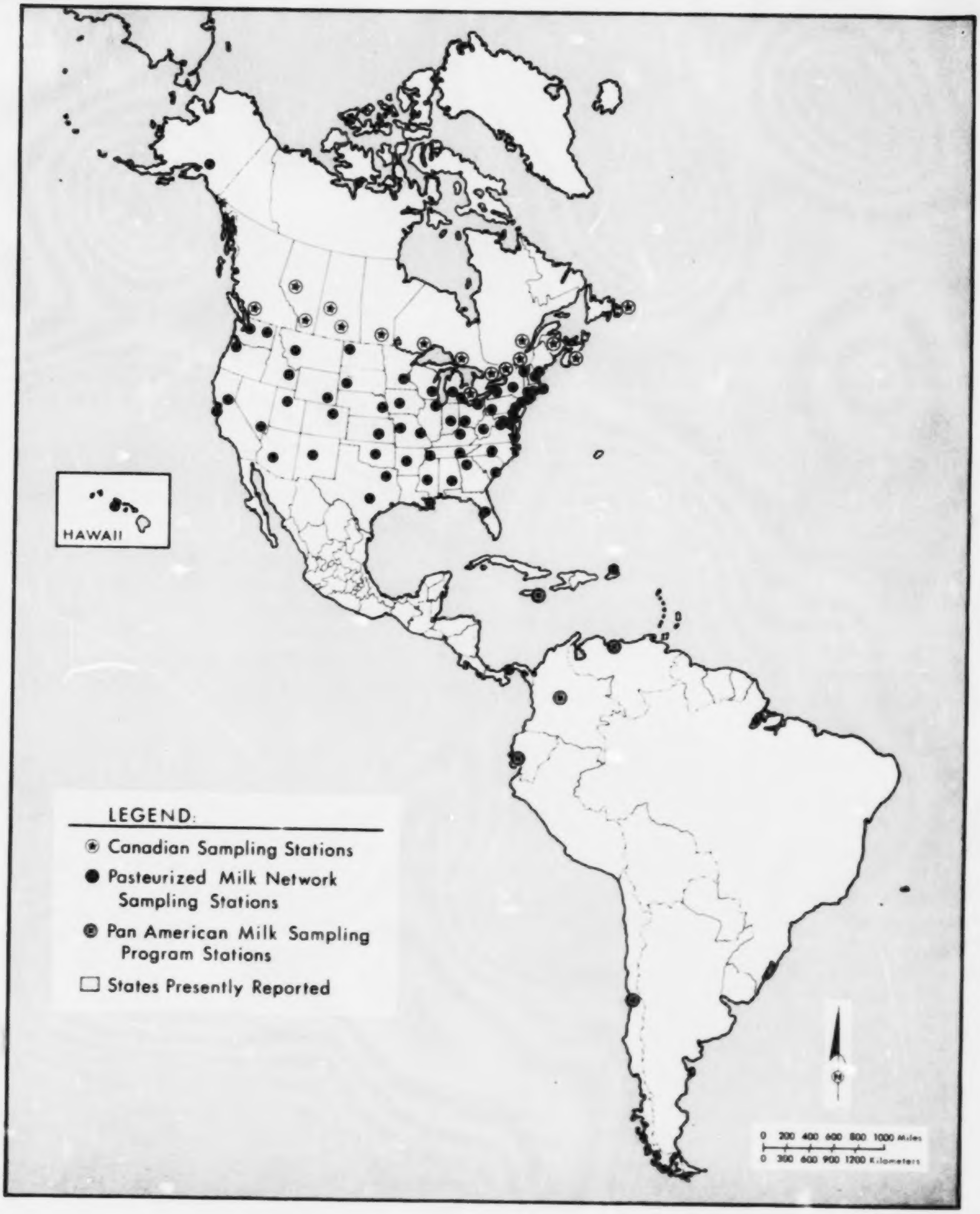
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
⊙ Pan American Milk Sampling Program Stations
☐ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers
N

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963—March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the network reports in *Radiation Data and Reports*, 13 participated in this study.

The accuracy results of this study for these 13 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addi-

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category				Experimental 2σ error (pCi/liter)
		Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131:	(96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
	(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137:	(53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
	(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89:	(29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
	(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90:	(32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
	(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

tion, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and is used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integratetd results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported in *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown

Table 2. Concentrations of radionuclides in milk for January 1973 and 12-month period February 1972 through January 1973

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	6	5	0	6
Alaska:	Palmer [c]	P	3	4	0	6
Ariz:	Phoenix [c]	P	0	0	0	0
Ark:	Little Rock [c]	P	6	10	0	4
Calif:	Sacramento [c]	P	0	1	0	0
	San Francisco [c]	P	0	0	0	0
	Del Norte	P	10	11	14	8
	Fresno	P	0	1	0	8
	Humboldt	P	3	3	0	4
	Los Angeles	P	0	1	0	2
	Mendocino	P	0	3	0	5
	Sacramento	P	0	2	0	4
	San Diego	P	0	1	0	4
	Santa Clara	P	0	1	0	4
	Shasta	P	2	2	0	6
	Sonoma	P	2	2	0	4
Colo:	Denver [c]	P	8	3	0	1
	East	R	NA	NA	0	3
	Northeast	R	NS	NA	NS	1
	Northwest	R	NS	NA	NS	0
	South Central	R	NS	NS	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NA	NA	[d] 0	2
	West	R	NS	NA	NS	4
Conn:	Hartford [c]	P	5	5	0	6
	Central	P	7	7	14	13
Del:	Wilmington [c]	P	4	8	0	7
D.C:	Washington [c]	P	4	6	0	5
Fla:	Tampa [c]	P	4	5	34	36
	Central	R	NS	5	NS	43
	North	R	8	6	12	14
	Northeast	R	7	5	22	32
	Southeast	R	5	5	63	53
	Tampa Bay area	P	6	5	23	35
	West	R	10	8	0	13
Ga:	Atlanta [c]	P	NS	9	NS	10
Hawaii:	Honolulu [c]	P	0	2	0	1
Idaho:	Idaho Falls [c]	P	3	4	0	0
Ill:	Chicago [c]	P	3	5	0	8
Ind:	Indianapolis [c]	P	3	5	0	8
	Central	P	5	7	10	10
	Northeast	P	6	6	0	10
	Northwest	P	7	8	10	11
	Southeast	P	5	8	0	9
	Southwest	P	6	7	10	11
Iowa:	Des Moines [c]	P	5	4	0	0
	Iowa City	P	NS	7	0	7
	Des Moines	P	4	6	0 (2)	5
	Little Cedar	P	NS	7	0	7
	Le Mars	P	NS	3	12	6
Kans:	Wichita [c]	P	6	6	0	0
	Coffeyville	P	NA		0	9
	Dodge City	P	NA		0	6
	Falls City, Nebr	R	NA		0	7
	Hays	P	NA		0	7
	Kansas City	P	NA		14	8
	Topeka	P	NA		0	7
	Wichita	P	NA		0	5
Ky:	Louisville [c]	P	5	7	0	4
La:	New Orleans [c]	P	7	12	0	3
Maine:	Portland [c]	P	7	6	13	22
Md:	Baltimore [c]	P	5	6	0	6
Mass:	Boston [c]	P	4	6	14	14
Mich:	Detroit [c]	P	6	7	0	7
	Grand Rapids [c]	P	7	7	0	5
	Bay City	P	0	3	0	6
	Charlevoix	P	0	4	0	9
	Detroit	P	4	3	0	7
	Grand Rapids	P	0	3	0	7
	Lansing	P	0	3	0	8
	Marquette	P	0	4	15	17
	Monroe	P	0	2	0	4
	South Haven	P	5	4	0	7
Minn:	Minneapolis [c]	P	7	7	0	14
	Bemidji	P	8	7	12	17
	Duluth	P	15	15	19	25
	Fergus Falls	P	8	7	10	13
	Little Falls	P	15	17	16	39
	Mankato	P	4	5	12	11
	Marshall	P	8	5	5	12

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for January 1973 and 12-month period February 1972 through January 1973—continued

Sampling location		Type of sample ᵃ	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average ᵇ	12-month average	Monthly average ᵇ	12-month average
UNITED STATES:						
Minn:—continued						
	Minneapolis	P	9	10	9	14
	Rochester	P	7	7	4	16
Miss:	Jackson ᵉ	P	8	9	0	7
Mo:	Kansas City ᵉ	P	5	5	0	1
	St. Louis ᵉ	P	6	6	0	2
Mont:	Helena ᵉ	P	3	4	0	2
Nebr:	Omaha ᵉ	P	4	5	0	1
Nev:	Las Vegas ᵉ	P	0	1	0	0
N.H:	Manchester ᵉ	P	10	8	0	14
N.J:	Trenton ᵉ	P	6	7	0	6
N. Mex:	Albuquerque ᵉ	P	0	1	0	0
N.Y:	Buffalo ᵉ	P	3	5	0	4
	New York City ᵉ	P	7	8	0	6
	Syracuse ᵉ	P	7	6	0	6
	Albany	P	2	5	0 (5)	0
	Buffalo	P	5	6	0	0
	Massena	P	NS	7	NS	0
	New York City	P	4	6	10	0
	Syracuse	P	6	4	NA	0
N.C:	Charlotte ᵉ	P	6	8	8 (2)	6
N. Dak:	Minot ᵉ	P	9	9	0	5
Ohio:	Cincinnati ᵉ	P	3	5	0	4
	Cleveland ᵉ	P	5	6	0	6
Okla:	Oklahoma City ᵉ	P	4	5	0	2
Oreg:	Portland ᵉ	P	0	4	0	3
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia ᵉ	P	4	6	0	3
	Pittsburgh ᵉ	P	7	8	0	8
	Dauphin	P	3	4	0	8
	Erie	P	5	6	0	7
	Philadelphia	P	0	5	12	8
	Pittsburgh	P	5	7	0	10
R.I:	Providence ᵉ	P	6	6	14	10
S.C:	Charleston ᵉ	P	8	8	0	12
S. Dak:	Rapid City ᵉ	P	3	5	0	1
Tenn:	Chattanooga ᵉ	P	5	8	11	8
	Memphis ᵉ	P	6	7	0	1
	Chattanooga	P	9	10	0	11
	Clinton	P	4	9	6 (2)	13
	Fayetteville	R	7	10	13 (3)	8
	Kingston	R	7	10	0	7
	Knoxville	P	5	8	5 (2)	7
	Lawrenceburg	R	6	8	0	9
	Nashville	P	7	8	0	6
	Pulaski	R	6	6	4	8
	Sequoyah	R	NS	8	NS	15
Tex:	Austin ᵉ	P	0	2	0	0
	Dallas ᵉ	P	3	5	0	0
	Amarillo	R	NS	3	NS	0
	Corpus Christi	R	NS	4	NS	0
	El Paso	R	NS	2	NS	0
	Fort Worth	R	4	4	0	0
	Harlingen	R	7	5	0	0
	Houston	R	7	8	0	0
	Lubbock	R	NS	3	NS	0
	Midland	R	NS	2	NS	0
	San Antonio	R	4	4	0	0
	Texarkana	R	NS	13	NS	0
	Tyler	R	15	15	0	0
	Uvalde	R	NS	—	NS	—
	Wichita Falls	R	NS	5	NS	0
Utah:	Salt Lake City ᵉ	P	2	3	12	3
Vt:	Burlington ᵉ	P	3	5	0	11
Va:	Norfolk ᵉ	P	6	6	16	7
Wash:	Seattle ᵉ	P	4	8	0	1
	Spokane ᵉ	P	4	4	0	5
	Benton County	R	3	1	0	0
	Franklin County	R	NS	1	NS	0
	Longview	R	0	4	0	2
	Sandpoint, Idaho	R	6	8	0	9
	Skagit County	R	5	7	0	4
W. Va:	Charleston ᵉ	P	5	7	0	5
Wisc:	Milwaukee ᵉ	P	NS	5	NS	7
Wyo:	Laramie ᵉ	P	0	2	0	0

See footnotes at end of table.

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Table 2. Concentration of radionuclides in milk for January 1973 and 12-month period February 1972 through January 1973—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:					
Alberta: Calgary	P	NA		18	14
Edmonton	P	NA		11	19
British Columbia:					
Vancouver	P	NA		18	19
Manitoba: Winnipeg	P	NA		11	16
New Brunswick:					
Moncton	P	NA		9	8
Newfoundland:					
St. John's	P	NA		14	23
Nova Scotia:					
Halifax	P	NA		7	15
Ontario: Ottawa	P	NA		6	10
Sault Ste. Marie	P	NA		17	22
Thunder Bay	P	NA		18	19
Toronto	P	NA		13	9
Windsor	P	NA		5	7
Quebec: Montreal	P	NA		10	10
Quebec	P	NA		14	20
Saskatchewan:					
Regina	P	NA		8	12
Saskatoon	P	NA		7	13
CENTRAL AND SOUTH AMERICA:					
Canal Zone:					
Cristobal [e]	P	0	1	11	10
Chile: Santiago	P	0	1	0	1
Colombia: Bogota	P	0	1	0	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Montego Bay	P	NS	2	NS	48
Puerto Rico:					
San Juan [e]	P	0	1	0	3
Venezuela: Caracas	P	NS	0	NS	0
PMN network average [e]		4	5	2	5

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply; the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for January 1973 and the 12-month period, February 1972 to January 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from

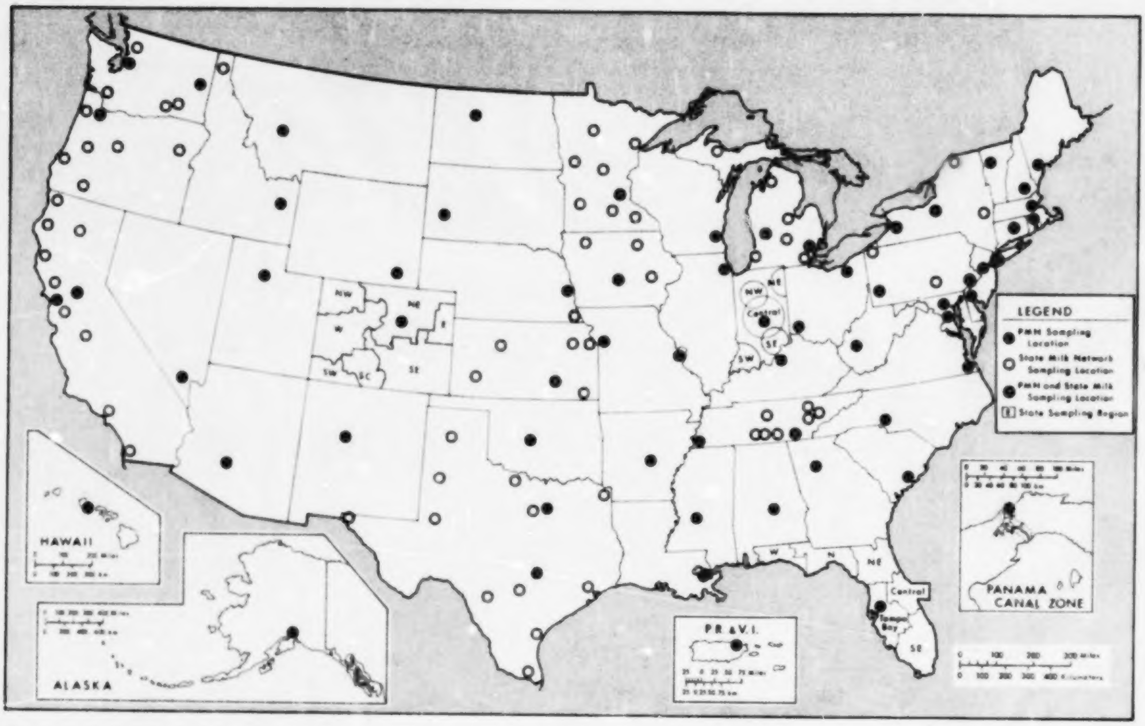
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
State Sampling Region
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
NW
NE
W
E
SW
SC
SE
Central
N
Tampa Bay

Figure 2. State and PMN milk sampling stations in the United States

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table 2 since levels at the majority of the stations for January 1973 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Table 3. Strontium-89, iodine-131, and barium-140 in milk, January 1973 [a]

Sampling location		Iodine-131 (pCi/liter)	Barium-140 (pCi/liter)
Fla:	Northeast (State)	11	
	North (State)		15
	Southeast (State)		17
	West (State)		16
Tenn:	Pulaski (State)	10	

[a] Strontium-89: 6pCi/liter for Santiago, Chile (PAHO).

Strontium-90 monthly averages ranged from 0 to 15 pCi/liter in the United States for January 1973, and the highest 12-month average was 17 pCi/liter (Little Falls, Minn.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 63 pCi/liter in the United States for January 1973, and the highest 12-month average was 53 pCi/liter (southeast Florida) representing 1.5 percent of the value derived from the recommendations given in the Federal Radiation Council Report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Bureau of Radiological Health
Environmental Health & Consumer Protection Program
California Department of Public Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

REFERENCES

(1) CAMPBELL, J. E., G. K. MURPHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

(2) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(5) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ-1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

(6) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(7) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Milk Surveillance Programs, November 1972

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Milk Surveillance Network, operated by the National Environmental Research Center-Las Vegas (NERC-LV)[1] consists of 30 sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.

In the event of a release of radioactivity from the NTS, special sampling within the affected

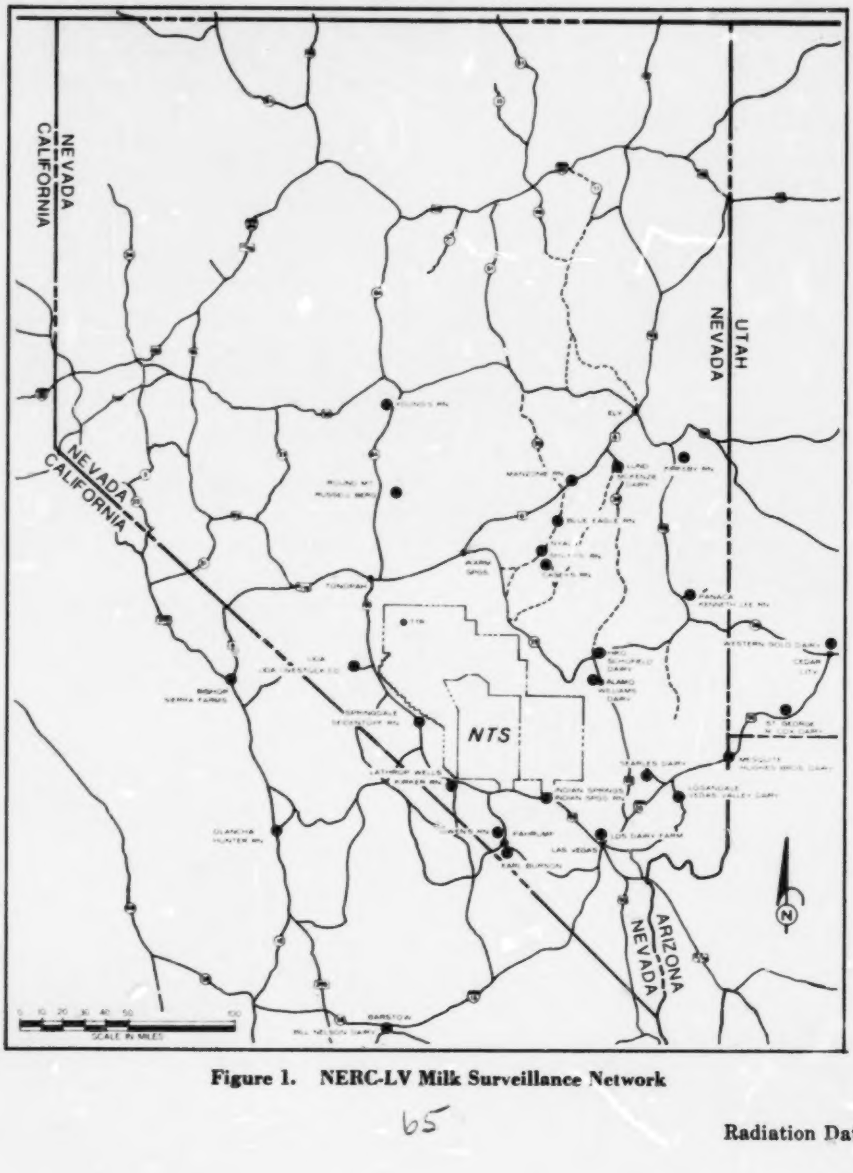
NEVADA
CALIFORNIA
UTAH
NEVADA
ARIZONA
NEVADA
NTS
ELY
TONOPAH
LUND
McKENZIE
DAIRY
BLUE EAGLE RN
ROUND MT.
WARM SPGS.
PANACA
KENNETH LEE RN
WESTERN GOLD DAIRY
CEDAR CITY
ST. GEORGE
MESQUITE
HUGHES BROS. DAIRY
ALAMO
WILLIAMS
DAIRY
LOGANDALE
VEGAS VALLEY DAIRY
INDIAN SPRINGS
LATHROP WELLS
SPRINGDALE
BISHOP
OLANCHA
HUNTER RN
PAHRUMP
EARL BURSON
LAS VEGAS
BARSTOW
SCALE IN MILES
N

Figure 1. NERC-LV Milk Surveillance Network

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[1] This network is operated under a Memorandum of Understanding (No. AT (26-1)-539 with the Nevada Operations Office, AEC, Las Vegas, Nev.

area is conducted to determine radionuclide concentrations and to take protective action, if required. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the December 1972 issue of *Radiation Data and Reports.*

Results

The analytical results of all milk samples collected in November 1972 by NERC-LV surveillance programs are listed in table 1. With the exception of cesium-137 at levels near the minimum detectable activity (MDA) of 10 pCi/liter, no gamma-emitting fission products were identified by gama spectrometry in any of the samples collected in November. Levels of trit-

Table 1. Milk surveillance results, November 1972

Location	Map number	Date collected (1972)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
California:							
Bishop:							
Sierra Farms	5	14	11	<10	<2.0	<1.3	NA
Hinkley:							
Bill Nelson Dairy	13	13	12	<10	<2.0	1.5 ± 1.0	NA
Independence:							
Smith Ranch	14	14	13	<10	<2.0	2.0 ± 1.2	NA
Nevada:							
Alamo:							
Williams Dairy	1	1	12	<10	<2.0	<1.0	NA
Austin:							
Young's Ranch	3	1	13	<10	<2.0	2.4 ± 1.4	NA
Belmont:							
Pine Creek Ranch	4	1	13	10	<4.0	8.0 ± 2.0	NA
Caliente:							
Tennille Ranch	6	2	13	<10	<2.0	4.0 ± 2.0	NA
Currant:							
Blue Eagle Ranch	7	15	13	<10	<2.0	2.0 ± 2.0	NA
Eureka:							
Martin Ranch	10	1	13	20	<4.0	5.3 ± 2.4	NA
Hiko:							
Schofield Dairy	12	1	12	<10	<2.0	1.6 ± 1.3	<210
Indian Springs:							
Indian Springs Ranch	15	2	13	<10	<2.0	4.0 ± 1.0	NA
Las Vegas:							
Anderson Dairy	17	7	11	<10	<2.0	2.2 ± 1.3	NA
Arden Dairy	18	7	11	<10	<2.0	2.2 ± 1.3	NA
LDS Dairy Farms	19	7	12	<10	<2.0	2.9 ± 1.5	<240
Lida:							
Lida Livestock Company	21	1	13	<10	<2.0	2.1 ± 1.2	NA
Logandale:							
Vegas Vally Dairy	22	1	12	<10	<2.0	<1.0	NA
Lund:							
McKenzie Dairy	23	15	12	<10	<2.0	<1.0	<190
McGill:							
Larsen Ranch	24	14	13	<10	<2.0	<1.0	NA
Mesquite:							
Hughes Bros. Dairy	25	1	12	<10	<2.0	2.0 ± 1.0	210 ± 190
Moapa:							
Searles Dairy	26	1	12	<10	<2.0	<1.0	NA
Nyala:							
Sharp's Ranch	28	14	13	<10	NA	NA	<190
Pahrump:							
Owens Ranch	31	2	13	<10	NA	NA	NA
Panaca:							
Kenneth Lee Ranch	33	2	13	<10	<2.0	3.3 ± 1.3	NA
Shoshone:							
Kirkeby Ranch	35	13	13	<10	<2.0	<2.0	NA
Springdale:							
Seidentopf Ranch	36	2	13	<10	<2.0	2.0 ± 1.0	NA
Utah:							
Garrison:							
Gonders Ranch	11	14	13	<10	<2.0	2.0 ± 1.0	NA
Newcastle:							
Newcastle Dairy	27	2	12	<10	<2.0	<1.0	NA
St. George:							
R. Cox Dairy	37	2	12	<10	<2.0	2.0 ± 1.0	NA

[a] 11—pasteurized milk.
12—Raw milk from Grade A producer(s).
13—raw milk from family cow(s).

[b] Two-sigma counting error provided when available.
NA, not analyzed.

ium and strontium-90 near the MDA's for these radionuclides (~200 pCi/liter and ≅1 pCi/liter, respectively) were also measured by radiochemistry analyses. Copies of these results were distrbuted to EPiA Regonal Offices and appropriate State agencies prior to publication.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1971	December 1972
Carbon-14 in Total Diet and Milk	July–December 1971	May 1972
Institutional Total Diet	October–December 1971 and 1971 Annual Summary	June 1972
Radiostrontium in Milk	January December 1971	November 1972
Strontium-90 in Tri-City Diets	January December 1971	December 1972

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SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January–December 1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January–December 1971	February 1973
Michigan	January–June 1970	November 1971
Minnesota	July 1970–June 1971	November 1972
New York	July–December 1970 and January–June 1971	May 1972
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	July–December 1971	November 1972
Tritium Surveillance System	July–September 1972	February 1973
Washington	July 1969–June 1970	March 1972
Water Surveillance Programs, *NERC-LV*	October 1972	April 1973

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

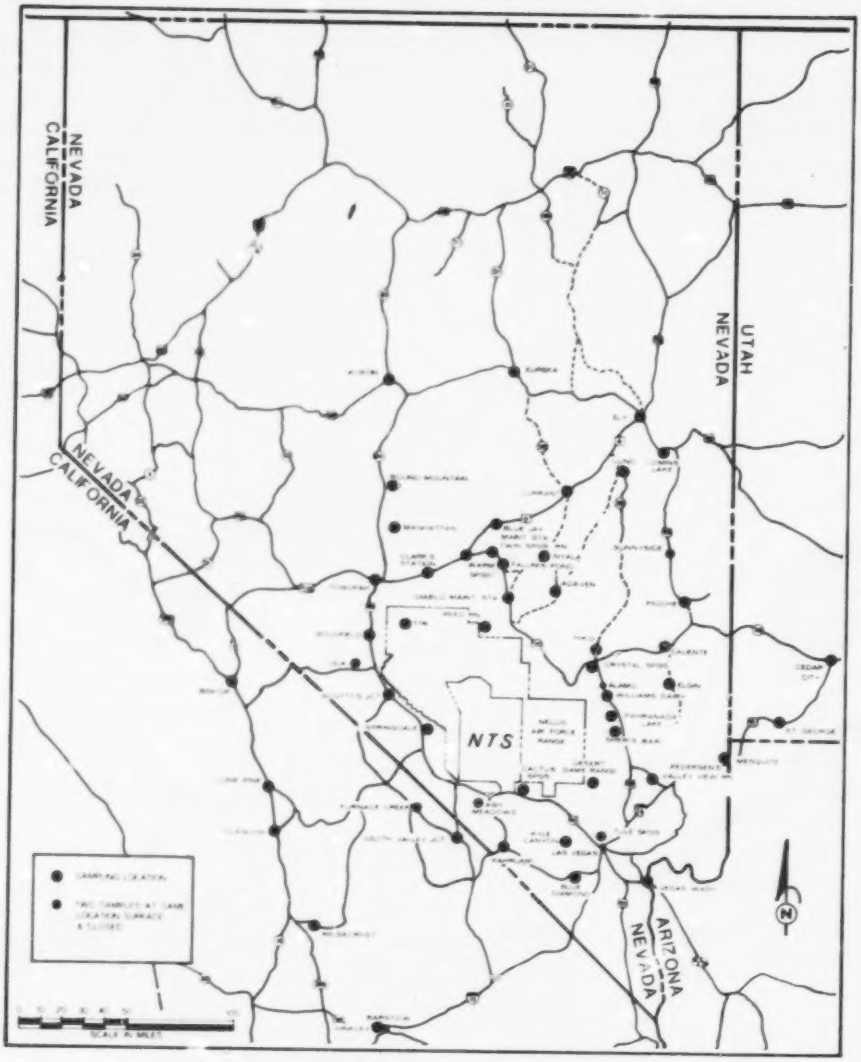
(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Water Surveillance Programs, November 1972

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Water Surveillance Network,[1] operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 90 sampling locations (figures 1 and 2) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.


NEVADA
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NEVADA
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ELY
ROUND MOUNTAIN
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CURRANT
BLUE JAY
CLARK'S STATION
TONOPAH
NYALA
SUNNYSIDE
PIOCHE
CALIENTE
CRYSTAL SPGS
ALAMO
ELGIN
CEDAR CITY
ST GEORGE
MESQUITE
NTS
NELLIS AIR FORCE RANGE
CACTUS SPGS
ASH MEADOWS
FURNACE CREEK
LAS VEGAS
BLUE DIAMOND
BISHOP
LONE PINE
BARSTOW
SAMPLING LOCATION
TWO SAMPLES AT SAME LOCATION SURFACE & CLOSED
SCALE IN MILES
0
10
20
30
40
50
100
N

Figure 1. NERC-LV Water Surveillance Network

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[1] This network is operated under a Memorandum of Understanding (No. AT (26–1)–539) with the Nevada Operations Office, AEC, Las Vegas, Nev.

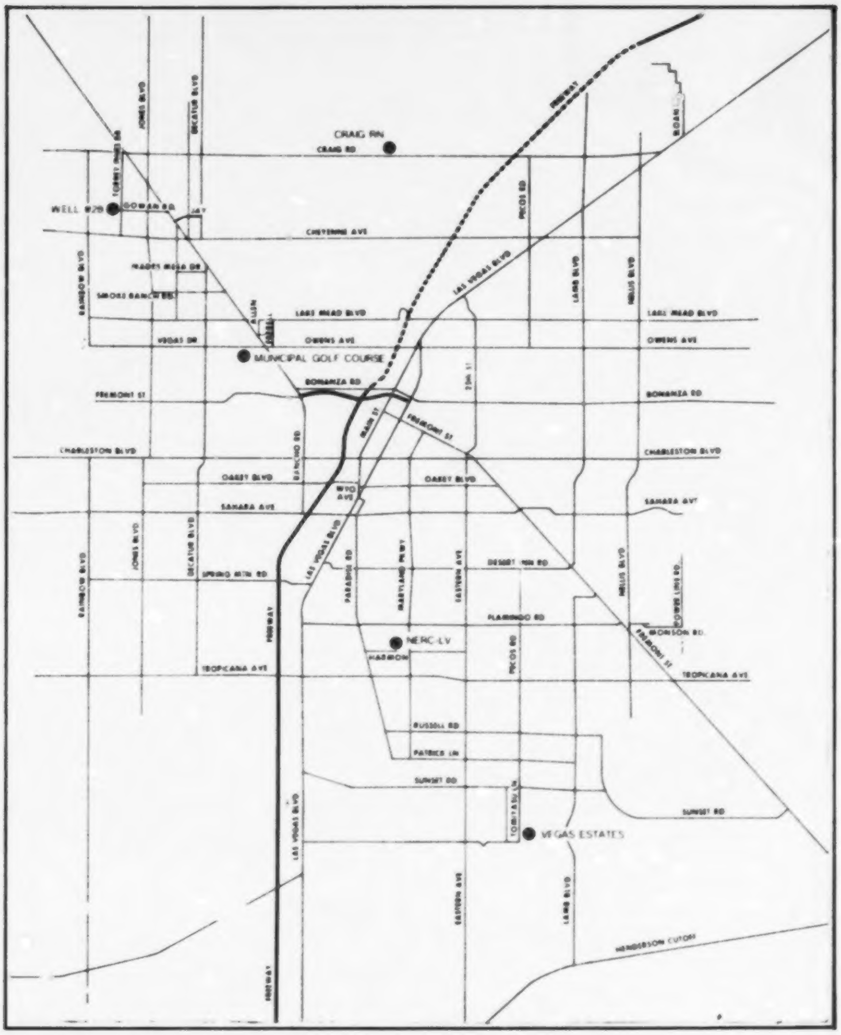
CRAIG RN
CRAIG RD
WELL #28
GOWAN RD
JAY
CHEYENNE AVE
TORREY PINES DR
JONES BLVD
DECATUR BLVD
RAINBOW BLVD
SMOKE RANCH RD
ALLEN
LAKE MEAD BLVD
VEGAS DR
OWENS AVE
MUNICIPAL GOLF COURSE
BONANZA RD
FREMONT ST
FREEWAY
LAS VEGAS BLVD
PECOS RD
LAMB BLVD
NELLIS BLVD
ROAN
25th ST
MAIN ST
CHARLESTON BLVD
RANCHO RD
OAKEY BLVD
WYO AVE
SAHARA AVE
SPRING MTN RD
PARADISE RD
MARYLAND PKWY
EASTERN AVE
DESERT INN RD
POWER LINE RD
FLAMINGO RD
MORISON RD
NERC-LV
HARMON
TROPICANA AVE
RUSSELL RD
PATRICK LN
SUNSET RD
TOMIYASU LN
VEGAS ESTATES
HENDERSON CUTOFF

Figure 2. Water Surveillance Network—Las Vegas Valley

In the event of a release of radioactivity from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations and to take protective action, if required. Additional water sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and routine analytical procedures was included with the water results reported in the December 1972 issue of *Radiation Data and Reports.*

For the purpose of identifying the source of the gross radioactivity in all network samples, and comparing sample concentrations with both the AEC Concentration Guides and the PHS Drinking Water Standards, selected samples from each sampling location are given special analyses at least once a year beginning with calendar year 1972. For surface water samples, the special analyses includes strontium-89, strontium-90, plutonium-238, plutonium-239, uranium, and radium-226. For drinking water

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Table 1. NERC-LV water surveillance results, November 1972

Location	Data collected 1972	Sample type [a]	Radioactivity concentration [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	14	23	<1.6	<3.4	NA
Owens River, 3 miles east	14	22	4.2 ± 3.8	5.4 ± 3.6	NA
Death Valley Junction:					
Lila's Cafe	15	24	<5.3	9.5 ± 4.0	<210
Furnace Creek:					
Pond	15	21	<4.8	9.2 ± 3.9	NA
Visitors Center	15	24	<5.2	9.4 ± 4.0	NA
Hinkley:					
Bill Nelson Dairy	13	23	11 ± 7.2	5.6 ± 3.7	NA
Little Lake:					
Little Lake Ranch	13	21	<7.7	32 ± 5.2	NA
Lone Pine:					
Diaz Lake	14	21	26 ± 10	41 ± 5.5	NA
Forest Service Ranger Station	14	23	<2.1	<3.5	NA
Olancha:					
Haiwee Reservoir	13	21	9.0 ± 4.8	8.7 ± 3.6	NA
Ridgecrest:					
City Hall	13	23	<3.2	5.4 ± 3.6	NA
Shoshone:					
Chevron Service Station	14	27	<4.5	17 ± 4.4	NA
Nevada:					
Adaven:					
Canfield Ranch	14	22	<3.5	<3.7	NA
Alamo:					
Sheri's Bar	1	23	<4.5	<3.8	NA
Pahranagat Lake	1	21	22 ± 9.3	22 ± 4.9	NA
Williams Dairy	1	23	<6.1	9.0 ± 4.0	NA
Ash Meadows:					
Ash Meadows Lodge	1	23	10 ± 7.9	16 ± 4.6	<220
Ash Meadows Pond	1	21	<7.5	15 ± 4.7	NA
Austin:					
County Courthouse	1	27	<3.8	15 ± 4.5	NA
Beatty:					
Richfield Service Station	1	23	10 ± 6.8	8.0 ± 4.0	<220
Blue Diamond:					
Post Office	1	23	<5.3	<4.0	<240
Blue Jay Highway:					
Maintenance Station	14	23	<4.1	<3.7	NA
Cactus Springs:					
Mobil Service Station	2	27	<3.5	<3.9	<240
Caliente:					
Agricultural Extension Station	2	23	7.0 ± 5.0	<3.8	NA
Meadow Valley Wash	2	22	<6.3	<3.9	NA
Clark Station:					
Five Mile Ranch	14	27	<4.1	<3.7	NA
Coyote Summit:					
Sand Spring Well	4	23	41 ± 11	21 ± 4.7	NA
Currant:					
Currant Pond	15	21	5.0 ± 4.0	<3.7	NA
Currant Ranch Cafe	15	27	5.0 ± 4.0	<3.7	NA
Diablo Highway:					
Maintenance Station	14	23	<4.2	<3.7	NA
Diablo:					
Reed Ranch	13	21	15 ± 7.0	18 ± 4.5	NA
Elgin:					
Water tower	2	23	8.0 ± 6.0	9.0 ± 4.0	NA
Ely:					
Chevron Service Station	14	24	3.0 ± 3.0	<3.7	NA
Comins Lake	13	21	9.0 ± 6.0	29 ± 5.0	NA
Eureka:					
Chevron Service Station	14	24	<3.9	<3.7	NA
Glendale:					
Chevron Service Station	1	27	<6.1	7.0 ± 4.0	NA
Muddy River	1	22	19 ± 8.0	25 ± 5.0	NA
Goldfield:					
Alkali Springs	2	21	<9.7	18 ± 5.1	NA
Chevron Service Station	2	23	<5.6	<4.0	NA
Hiko:					
Crystal Springs	1	27	4.0 ± 4.0	5.0 ± 4.0	NA
Schofield Dairy	1	23	20 ± 8.4	26 ± 5.0	NA
Indian Springs:					
Chevron Service Station	2	23	<4.1	<3.9	<220
Las Vegas:					
Cal-Nev Jet Fuels	6	23	<3.5	<3.7	<220
Craig Ranch Golf Course	6	23	<3.5	5.0 ± 4.0	<220
Cunningham Ranch	6	23	<3.3	<3.7	<220
Desert Game Range	2	23	<3.8	<3.9	<220
Desert Game Range Pond	2	21	<3.9	<3.9	<220
Francis Residence	6	23	<5.7	<3.8	<220
Lab II, NERC-LV	6	24	<5.9	6.0 ± 4.0	880 ± 230
Lake Mead Vegas Wash	6	21	<6.0	5.0 ± 4.0	770 ± 230

See footnotes at end of table.

Table 1. NERC-LV water surveillance results, November 1972—continued

Location	Data collected 1972	Sample type [a]	Radioactivity concentration [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Nevada—continued					
Las Vegas:					
LDS Dairy Farm	7	23	<5.5	4.0 ± 4.0	<220
Lloyd Ranch	6	23	<6.0	<3.8	<220
LV Water District Well 28	6	23	<3.3	<3.7	<220
Municipal Golf Course	6	23	<3.4	<3.7	<220
Tule Springs	2	23	<3.8	<3.9	<220
Tule Springs Pond	2	21	<3.6	<3.9	NA
Vegas Estates	6	23	<6.6	7.0 ± 4.0	<220
Lathrop Wells:					
Texaco Service Station	1	23	<5.2	<4.0	<220
Lida Junction:					
Cottontail Ranch	1	23	<5.2	9.0 ± 4.0	NA
Lida:					
Lida Livestock Company	1	27	<4.5	<3.8	NA
Pond at storage tank	1	21	<4.3	<4.0	NA
Lund:					
Gardner Grocery	15	23	4.3 ± 3.6	<3.5	NA
Manhattan:					
Country Store	2	23	12 ± 6.9	7.0 ± 4.0	NA
Seyler Reservoir	1	21	12 ± 6.9	25 ± 5.0	NA
Mercury:					
Groom Lake	13	23	<4.2	<3.7	NA
Moapa:					
Pedersen Valley View Ranch	1	27	8.0 ± 5.0	9.0 ± 4.0	NA
Mt. Charleston:					
Kyle Canyon Fire Station	2	27	<4.0	<3.9	<220
Nyala:					
Sharp's Ranch	14	23	<3.5	<3.7	NA
Pahrump:					
Texaco Service Station	1	23	<3.7	<3.8	NA
Pioche:					
County Courthouse	2	24	<3.9	<3.8	NA
Round Mountain:					
Mobil Service Station	1	27	<3.4	<3.9	NA
Scotty's Junction:					
Chevron Service Station	1	23	<6.1	5.0 ± 4.0	<220
Springdale:					
Peacock Ranch	2	27	<5.4	6.0 ± 4.0	<220
Pond	2	21	<6.3	4.0 ± 4.0	NA
Sunnyside:					
Adam McGill Reservoir	15	21	7.7 ± 4.7	8.8 ± 3.8	NA
Wildlife Mgt. Headquarters	15	27	<3.2	<3.7	NA
Tonopah:					
Jerry's Chevron Station	2	23	<4.4	<4.0	NA
Tonopah Test Range CP-1	2	23	<4.4	4.0 ± 4.0	NA
Warm Springs:					
Fallini's Pond	14	21	24 ± 12	74 ± 7.1	NA
Hot Creek Ranch	14	27	<6.0	12 ± 4.3	NA
Service Station and Cafe	13	27	42 ± 12	36 ± 5.4	NA
Twin Springs Ranch	14	23	<4.1	4.0 ± 4.0	NA
Utah:					
Cedar City:					
M.D. Baldwin Residence	1	24	<3.6	<3.9	NA
Garrison:					
Rowley Grocery	14	23	<3.0	<3.5	NA
Newcastle:					
Municipal Reservior	1	21	<3.2	<3.9	NA
Newcastle Dairy	2	24	<5.6	<4.0	NA
St. George:					
R. Cox Dairy	2	24	<2.5	<3.9	NA

[a] 21-pond, lake, reservoir, stock tank, stock pond.
22-stream, river, creek.
23-well.
24-multiple supply-mixed water sample consisting of mixed or multiple sources of water, such as well or spring.
27-spring

[b] Two-sigma counting error provided when available.
NA, not analyzed.

samples, the analyses includes strontium-89, strontium-90, uranium, and radium-226.

Results

The routine analytical results of all water samples collected in November 1972 by the NERC-LV Water Surveillance Network are listed in table 1. No gamma-emitting fission products were identified by gamma spectrometry in any of the samples collected in November. The analytical results of samples selected for special analyses will be reported at a later date.

Copies of these results are distributed to EPA Regional Offices and appropriate State agencies prior to publication.

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Tritium Surveillance System, October-December 1972

Office of Radiation Programs
Environmental Protection Agency

The Tritium Surveillance System is an expansion of previous tritium surveillance activities initiated by the Public Health Service and transferred in 1970 to the Office of Radiation Programs, Environmental Protection Agency (EPA). The principal effort in the past related to tritium releases was the Tritium in Surface Water Network. This network was established in 1964 to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at surface water stations downstream from selected nuclear facilities. The network consisted of selected stations from the existing water pollution surveillance sampling stations. The final data from this network for January–June 1970, have been published previously (*1*).

Another sampling program of the Public Health Service was a tritium in precipitation program. This project was established in 1967 at selected Radiation Alert Network (RAN) stations covering the United States, including Alaska and Hawaii. The RAN is now operated by the Office of Air Programs of the EPA. The data from this project for July–December 1969 have been published previously (*2*). Due to the increased interest in tritium releases from nuclear facilities and the potential long-term accumulation in the environment, a national system was established to incorporate these projects or networks into one overall system.

Present network

The Tritium Surveillance System consists of 69 quarterly drinking water samples at the RAN stations, precipitation samples collected daily and analyzed monthly from 8 of the RAN stations (figure 1), and quarterly samples at 39 surface water stations (figure 2). The specific locations for the surface water sampling systems were determined by examining the water drainage areas to assure that a representative sample from a large area or region was obtained, and if possible, incorporating several nuclear facility sites. All nuclear facilities that were operating, being constructed, or planned through 1975 were considered. Consideration was also given to the current surveillance programs of the States that will be involved in the collection of the samples. The surface water samples are collected quarterly either downstream from a nuclear facility or at a background station.

The tap water samples are collected by the RAN operators on a quarterly basis. The precipitation samples are also collected by the RAN operators on a daily basis.

All samples are sent to either the Eastern Environmental Radiation Laboratory or the National Environmental Research Center—Las Vegas for analysis. Analytical values which are not statistically significant at the 2-sigma confidence level have been reported as zero.

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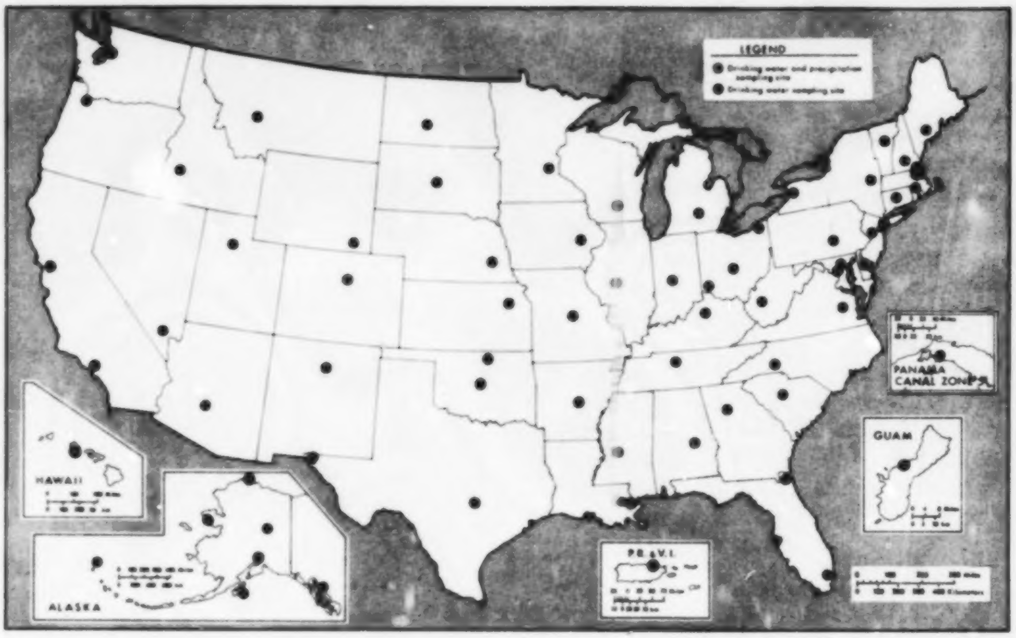
LEGEND
Drinking water and precipitation sampling site
Drinking water sampling site
HAWAII
ALASKA
P.R. & V.I.
GUAM
PANAMA CANAL ZONE

Figure 1. Drinking water and precipitation sampling locations for tritium surveillance system

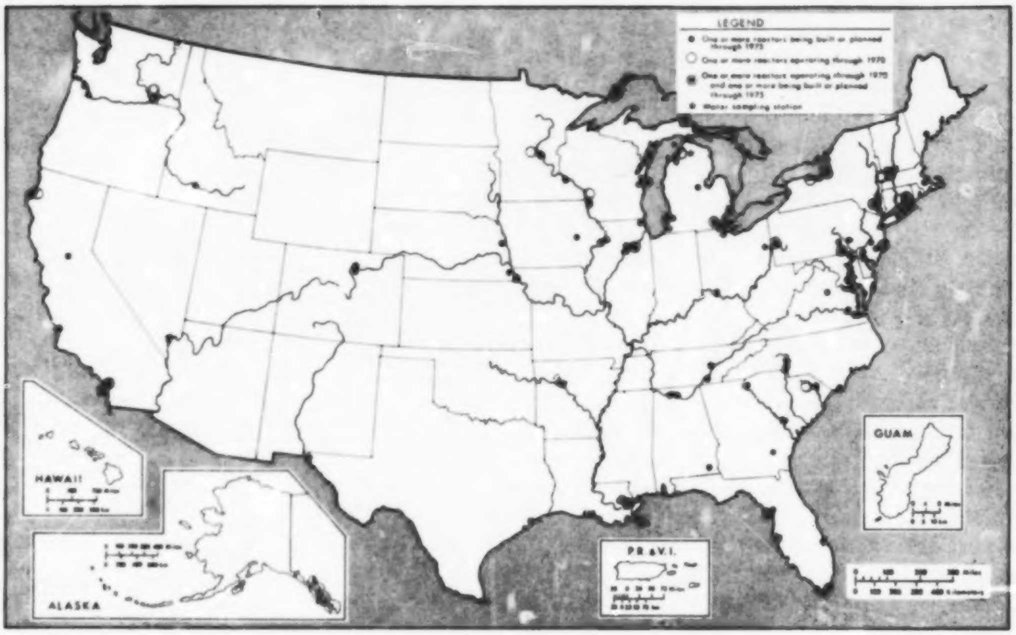
LEGEND
One or more reactors being built or planned through 1975
One or more reactors operating through 1970
One or more reactors operating through 1970 and one or more being built or planned through 1975
Water sampling station
HAWAII
ALASKA
P.R. & V.I.
GUAM

Figure 2. Surface water sampling locations for tritium surveillance system

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the RAN stations for October–December 1972. The average tritium concentration was 0.2 nCi/liter.

In previous articles on the Tritium Surveillance System, the reported dose equivalents from tritium in body water have been based on a relationship derived by Moghissi and Porter (*3*). Their relationship assumed a quality factor of 1.7 for tritium beta rays based on a 1966 ICRP recommendation (*4*). Recently the NCRP has recommended a quality factor of 1 for tritium beta rays (*5*) and this recommendation has been adopted for this and subsequent reports. Following the notation adopted by the ICRU (*6*) substitution of a quality factor of 1 in Moghissi and Porter calculations yields:

$$H\ (\text{mrem/year}) = 0.1C\ (\text{nCi/liter})$$

Where H is the dose equivalent rate and C represents the tritium concentration in body water.

Assuming that the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also that the specific activity of tritium in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

The highest individual concentration of tritium observed in the drinking water was 1.3 nCi/liter during the fourth quarter. This corresponds to a dose of 0.13 mrem/a, or less than 0.08 percent of the Federal Radiation Council's Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population.

The tritium concentrations for the surface water samples are given in table 2. The highest tritium concentration was 4.9 nCi/liter for the quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentration corresponds to a dose of .49 mrem/a, or 0.29 percent of the Radiation Protection Guide.

The monthly analyses for tritium in precipitation samples at the 8 RAN stations are shown in table 3.

Table 1. Tritium concentration in tap water (RAN stations) October–December 1972

Location		Date collected (1972)	Tritium concentration [a] (nCi/liter ±2σ)[b]
Ala:	Montgomery	10/3	0.0
Alaska:	Anchorage	NS	
	Attu Island	10/9	.2
	Fairbanks	NS	
	Juneau	10/5	0
	Nome	11/6	.6
	Point Barrow	10/12	.3
Ariz:	Phoenix	10/2	.3
Ark:	Little Rock	10/11	0
Calif:	Berkeley	10/2	0
	Los Angeles	10/4	0
C.Z:	Ancon	10/16	0
Colo:	Denver	10/11	.8
Conn:	Hartford	10/5	0
Del:	Dover	10/10	0
D.C:	Washington	10/13	0
Fla:	Jacksonville	10/5	0
	Miami	10/4	0
Ga:	Atlanta	10/3	.2
Guam:	Agana	10/2	0
Hawaii:	Honolulu	10/4	0
Idaho:	Boise	10/2	.5
Ill:	Springfield	10/13	.2
Ind:	Indianapolis	10/4	0
Iowa:	Iowa City	10/3	.4
Kans:	Topeka	11/6	0
Ky:	Frankfort	10/6	.3
La:	New Orleans	10/2	.5
Maine:	Augusta	10/4	0
Md:	Baltimore	10/5	.2
Mass:	Lawrence	10/5	0
	Winchester	10/4	.2
Mich:	Lansing	10/6	0
Minn:	Minneapolis	10/10	.5
Miss:	Jackson	10/3	0
Mo:	Jefferson City	10/3	0
Mont:	Helena	10/3	.6
Nebr:	Lincoln	10/4	.4
Nev:	Las Vegas	10/2	1.3 ±0.3
N.H:	Concord	10/5	.3
N.J:	Trenton	10/4	.2
N. Mex:	Santa Fe	10/2	.4
N.Y:	Albany	10/5	.2
	Buffalo	10/4	.3
	New York	10/4	.2
N.C:	Gastonia	10/4	.2
N. Dak:	Bismarck	10/17	.9
Ohio:	Cincinnati	10/4	0
	Columbus	10/5	.2
	Painesville	10/9	.3
Okla:	Oklahoma City	10/9	0
	Ponca City	10/2	.7
Ore:	Portland	10/9	0
Pa:	Harrisburg	10/6	.2
P.R:	San Juan	10/6	0
R.I:	Providence	10/12	.2
S.C:	Columbia	10/9	.3
S. Dak:	Pierre	10/2	1.1
Tenn:	Nashville	10/3	.2
Tex:	Austin	10/2	0
	El Paso	10/2	.2
Utah:	Salt Lake City	10/5	.5
Vt:	Barre	10/4	.2
Va:	Richmond	10/6	0
Wash:	Seattle	10/2	.5
	Spokane	10/3	.3
W. Va:	Charleston	10/4	0
Wisc:	Madison	10/11	0
Wyo:	Cheyenne	10/11	.8
Average			0.2

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.

[b] The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.

NS, no sample.

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Table 2. Tritium concentration in surface water, October–December 1972

Location		Water source	Facility	Collection date (1972)	Concentration [a] (nCi/liter ±2σ) [b]
Ala:	Decatur	Tennessee River	Browns Ferry	[c] 9/29	0.2
Ark:	Morrilton	Arkansas River	Arkansas Nuclear	10/11	0
Calif:	Eureka	Humboldt Bay	Humboldt Bay	NS	
	San Onofre	Pacific Ocean	San Onofre	10/1	.4
Colo:	Greely	South Platte River	Fort St: Vrain	10/13	1.0
Conn:	East Haddam	Connecticut River	Connecticut Yankee & Vermont Yankee	10/27	.5
	Waterford	Long Island Sound	Millstone	11/1	0
Fla:	Crystal River	Gulf of Mexico	Crystal River	10/5	0
	Homestead	Biscayne Bay	Turkey Point	12/6	0
Idaho:	Buhl	Snake River	National Reactor Testing Station	10/14	.4
Ill:	Moline	Mississippi River	Quad-Cities	10/31	.2
	Morris	Illinois River	Dresden and Argonne	10/18	.3
La:	New Orleans	Mississippi River	(Several)	10/5	.3
Md:	Conowingo	Susquehanna River	Peach Bottom and Three Mile Island	10/11	.2
	Lusby	Chesapeake Bay	Calvert Cliffs	10/25	.2
Mass:	Rowe	Deerfield River	Yankee	10/13	4.9
Mich:	Charlevoix	Lake Michigan	Big Rock Point	10/14	.9
	Monroe	Lake Erie	Enrico Fermi	10/16	.3
	South Haven	Lake Michigan	Palisades	10/13	0
Minn:	Monticello	Mississippi River	Monticello	10/9	.4
Nebr:	Rulo	Missouri River	Fort Calhoun and Cooper	10/4	.6
Nev:	Boulder City	Colorado River	Background	10/16	1.0
N.J:	Bayside	Delaware River	Salem	12/6	.2
N.Y:	Ossining	Hudson River	Indian Point	10/10	.3
	Oswego	Lake Ontario	Nine Mile Point and R. E. Ginna	10/10	.4
	Poughkeepsie	Hudson River	Background	10/11	.3
N.C:	Charlotte	Catawba River	Wm. B. McGuire	12/6	.3
Oreg:	Westport	Columbia River	Rainier and Hanford	10/12	.7
S.C:	Allendale	Savannah River	Savannah River Plant and Oconee	10/17	3.0
	Hartsville	Lake Robinson	H. B. Robinson	10/19	3.2
Tenn:	Kingston	Clinch River	Oak Ridge	10/31	4.8
Tex:	El Paso	Rio Grande	Los Alamos	10/2	.4
Vt:	Vernon	Connecticut River	Vermont Yankee	10/5	.2
Va:	Newport News	James River	Surry	10/13	.0
Wash:	Northport	Columbia River	Background	NS	
	Richland	Columbia River	Hanford	10/12	.7
W. Va:	Wheeling	Ohio River	Shippingport	10/11	.2
Wisc:	Two Creeks	Lake Michigan	Point Beach and Kewaunee	10/23	.4
	Victory	Mississippi River	LaCrosse and Prairie Island	10/16	.2
Average					0.7

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.
[b] The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.
[c] Sample collected early.
NS, no sample.

Table 3. Tritium concentration in precipitation from RAN stations, October–December 1972

Location		Tritium concentration [a] (nCi/liter ±2σ)		
		October	November	December
Ala:	Montgomery	0.2	0.0	0.0
Alaska:	Anchorage	NS	0	0
Colo:	Denver	NS	0	0
Hawaii:	Honolulu	0	0	0
La:	New Orleans	0	0	0
N.C:	Gastonia	0	0	0
Tex:	Austin	0	0	0
Wash:	Seattle	0	0	0

[a] The minimum detection limit for these samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero. The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.
NS, no sample.

Other coverage in *Radiation Data and Reports:*

Period	Issue
January–March 1972	August 1972
April–June 1972	January 1973
July–September 1972	February 1973

REFERENCES

(*1*) BUREAU OF RADIOLOGICAL HEALTH. Tritium in surface water network, January-June 1970. Radiol Health Data Rep 11: 638–639 (November 1970).

(*2*) BUREAU OF RADIOLOGICAL HEALTH. Tritium in precipitation (RAN), July–December 1969. Radiol Health Data Rep 11: 354–355 (July 1970).

(*3*) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9: 337–339 (July 1968).

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendations of the International Commission on Radiological Protection (Adopted September 17, 1965), ICRP Publication 9 (1969).

(*5*) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Basic Radiation Protection Criteria, NCRP Report No. 39, National Council on Radiation Protection and Measurements, Washington, D.C. 20008 (January 15, 1971).

(*6*) INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS. Radiation Quantities and Units, ICRU Report No. 19. Washington D.C. 20014 (July 1972).

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports*.

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January–December 1970	December 1971
Mexican air monitoring program	May–August 1972	January 1973
Plutonium in airborne particulates	July–September 1972	March 1973

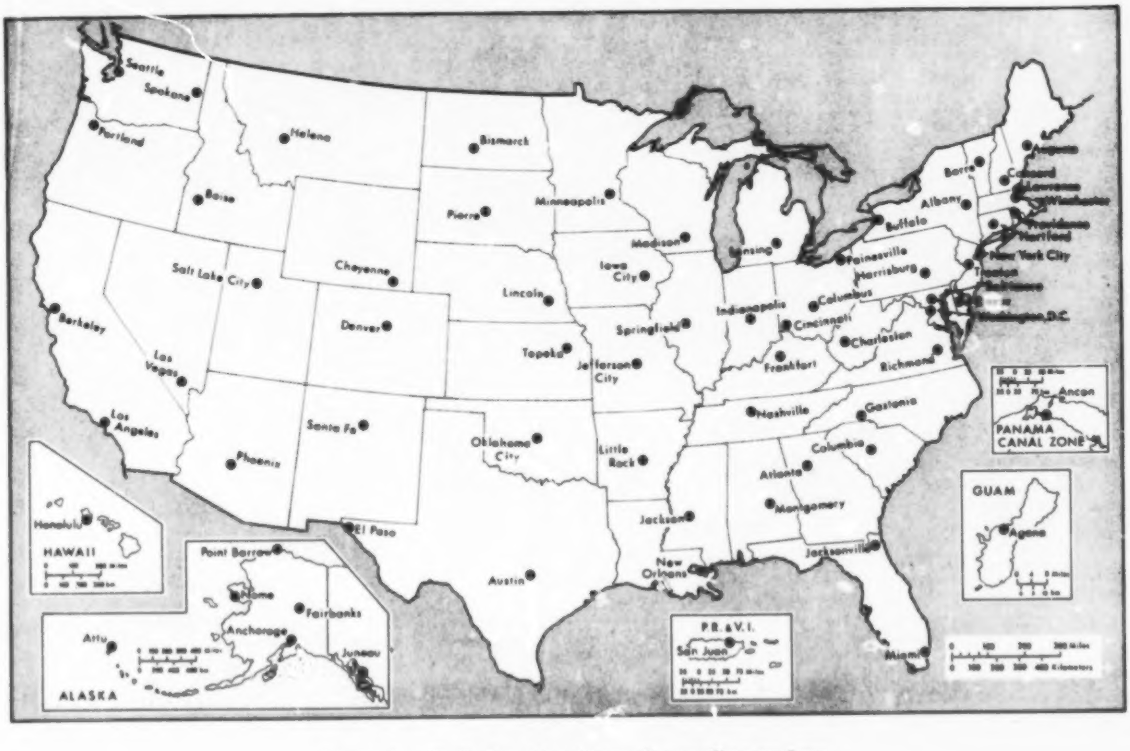
1. Radiation Alert Network
January 1973

Quality Assurance and Environmental Monitoring Laboratory, Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Quality Assurance and Environmental Monitoring Laboratory, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during January 1973.


Seattle
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Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Washington, D.C.
Painesville
Harrisburg
Columbus
Cincinnati
Charleston
Richmond
Frankfort
Indianapolis
Iowa City
Springfield
Jefferson City
Salt Lake City
Cheyenne
Lincoln
Denver
Topeka
Berkeley
Las Vegas
Los Angeles
Santa Fe
Phoenix
Oklahoma City
Little Rock
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Miami
El Paso
Austin
HAWAII
Honolulu
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Juneau
Attu
P.R. & V.I.
San Juan
PANAMA CANAL ZONE
Ancon
GUAM
Agana
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. Radiation Alert Network sampling stations

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Table 1. Gross beta radioactivity in surface air and precipitation, January 1973

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
						Number of samples	Field estimation of deposition			
			Maximum	Minimum	Average [a]		Total depth (mm)	Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	19	1	0	0	4	147	4	147	16
Alaska:	Anchorage	1	0	0	0	0	0			
	Attu Island	31	0	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	22	12	1	4	0				
Ark:	Little Rock	1	0	0	0	0				
Calif:	Berkeley	21	0	0	0	11	272	11	272	0
	Los Angeles	20	1	0	1	0				
C.Z:	Ancon	14	0	0	0	0				
Colo:	Denver	21	1	0	0	1	3	(b)		
Conn:	Hartford	21	1	0	0	7	86	7	86	0
Del:	Dover	20	1	0	0	0				
D.C:	Washington	0				0				
Fla:	Jacksonville	17	1	0	0	4	40	4	40	0
	Miami	0				0				
Ga:	Atlanta	20	1	0	0	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	21	1	0	0	3	23	(b)		
Idaho:	Boise	21	1	0	0	4	37	4	37	0
Ill:	Springfield	7	1	0	0	0				
Ind:	Indianapolis	19	1	0	0	0				
Iowa:	Iowa City	21	0	0	0	3	73	3	73	6
Kans:	Topeka	21	1	0	0	6	62	6	62	0
Ky:	Frankfort	14	1	0	1	0				
La:	New Orleans	18	1	0	0	7	70	(b)		
Maine:	Augusta	17	0	0	0	4	63	4	63	0
Md:	Baltimore	20	3	0	0	4	38	4	38	0
Mass:	Lawrence	22	0	0	0	4	96	4	96	4
	Winchester	20	1	0	0	6	113	6	113	0
Mich:	Lansing	21	0	0	0	0				
Minn:	Minneapolis	22	0	0	0	4	32	4	32	4
Miss:	Jackson	10	0	0	0	5	181	5	181	1
Mo:	Jefferson City	20	1	0	0	7	86	7	86	0
Mont:	Helena	19	2	0	1	0				
Nebr:	Lincoln	19	1	0	0	3	32	3	32	1
Nev:	Las Vegas	21	4	0	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	21	1	0	0	5	78	5	78	2
N. Mex:	Santa Fe	16	1	0	0	1	4	1	4	0
N.Y:	Albany	16	2	0	1	0				
	Buffao	22	0	0	0	0				
	New York City	0				0				
N.C:	Gastonia	19	6	0	1	2	9	(b)		
N. Dak:	Bismarck	21	2	0	1	0				
Ohio:	Cincinnati	0				0				
	Columbus	2	0	0	0	0				
	Painesville	21	0	0	0	6	31	6	31	8
Okla:	Oklahoma City	0				0				
Oreg:	Portland	20	1	0	0	12	137	12	137	10
Pa:	Harrisburg	17	2	0	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	19	1	0	0	0				
S.C:	Columbia	9	1	0	0	3	105	3	105	1
S. Dak:	Pierre	16	3	0	1	0				
Tenn:	Nashville	17	1	0	0	6	123	6	123	3
Tex:	Austin	20	4	0	1	6	90	(b)		
	El Paso	20	7	1	2	0				
Utah:	Salt Lake City	29	1	0	0	5	11	5	11	2
Vt:	Barre	21	1	0	0	5	59	5	59	8
Va:	Richmond	20	0	0	0	5	157	5	157	25
Wash:	Seattle	9	0	0	0	7	96	(b)		
	Spokane	19	1	0	0	0				
W. Va:	Charleston	19	2	0	0	6	34	6	34	3
Wisc:	Madison	21	0	0	0	5	71	5	71	4
Wyo:	Cheyenne	11	2	0	1	0				
Network summary		1,006	12	0	0	161	95	5	83	4

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[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

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2. Canadian Air and Precipitation Monitoring Program,[1] January 1973

Radiation Protection Division, Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for January 1973 are presented in table 2.

Table 2. Canadian gross beta radioactivity in air and precipitation, January 1973

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m^2)
Calgary	5	0.02	0.01	0.01	41	0.1
Coral Harbour	5	.04	.03	.03	12	.1
Edmonton	5	.03	.02	.02	39	.4
Ft. Churchill	4	.01	.01	.01	25	.2
Fredericton	4	.02	.01	.02	6	.6
Goose Bay	5	.03	.02	.02	3	.2
Halifax	5	.03	.02	.02	5	.4
Inuvik	4	.06	.02	.04	11	.3
Montreal	4	.05	.02	.03	6	.4
Moosonee	5	.02	.01	.01	27	.6
Ottawa	5	.03	.01	.02	5	.4
Quebec	5	.03	.01	.02	8	.7
Regina	4	.05	.02	.03	109	.1
Resolute	5	.05	.04	.04	24	.1
St. John's, Nfld	1	.00	<.01	.00	5	.4
Saskatoon	5	.04	.01	.01	32	.2
Sault Ste. Marie	5	.03	.02	.02	37	.6
Thunder Bay	3	.04	.02	.03	16	.4
Toronto	5	.01	.01	.01	17	.7
Vancouver	5	.01	.01	.01	6	1.0
Whitehorse	5	.06	.02	.03	NS	NS
Windsor	2	.01	.01	.01	13	.5
Winnipeg	5	.05	.02	.03	112	.3
Yellowknife	NS	NS	NS	NS	24	.3
Network summary	101	0.06	<0.01	0.02	25	0.4

NS, no sample.

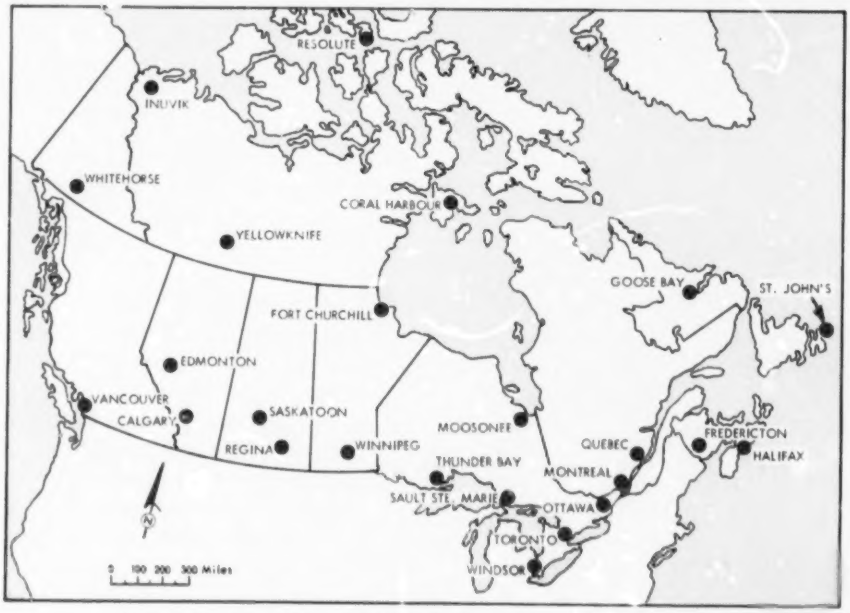
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 2. Canadian air and precipitation monitoring program

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program
January 1973

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The January 1973 air monitoring results from the participating countries are given in table 3.

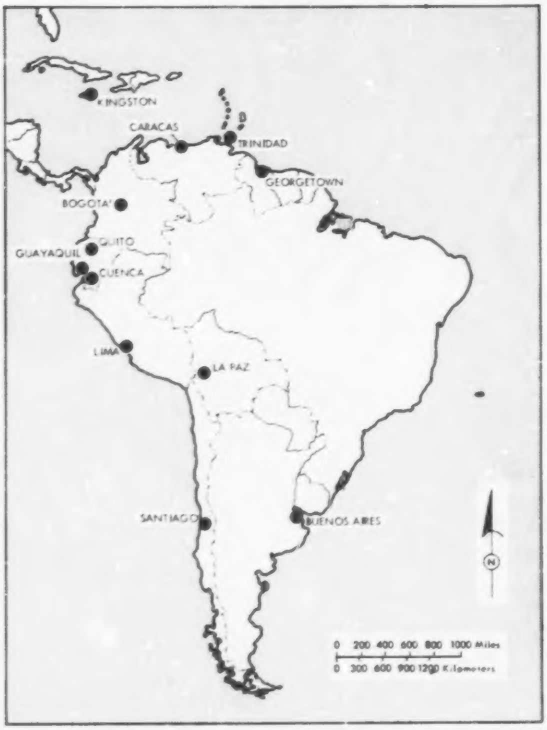

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, January 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	17	0.03	0.00	0.01
Chile:	Santiago	30	.05	.00	.03
Colombia	Bogota	22	.02	.00	.01
Ecuador:	Cuenca	1	.00	.00	.00
	Guayaquil	17	.03	.00	.01
	Quito	16	.01	.00	.00
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	12	.02	.00	.01
West Indies:	Trinidad	19	.05	.00	.02
Pan American summary		134	0.05	0.00	0.01

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging 0.00 pCi/m³.

4. California Air Sampling Program
January 1973

Bureau of Radiological Health, California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a con-

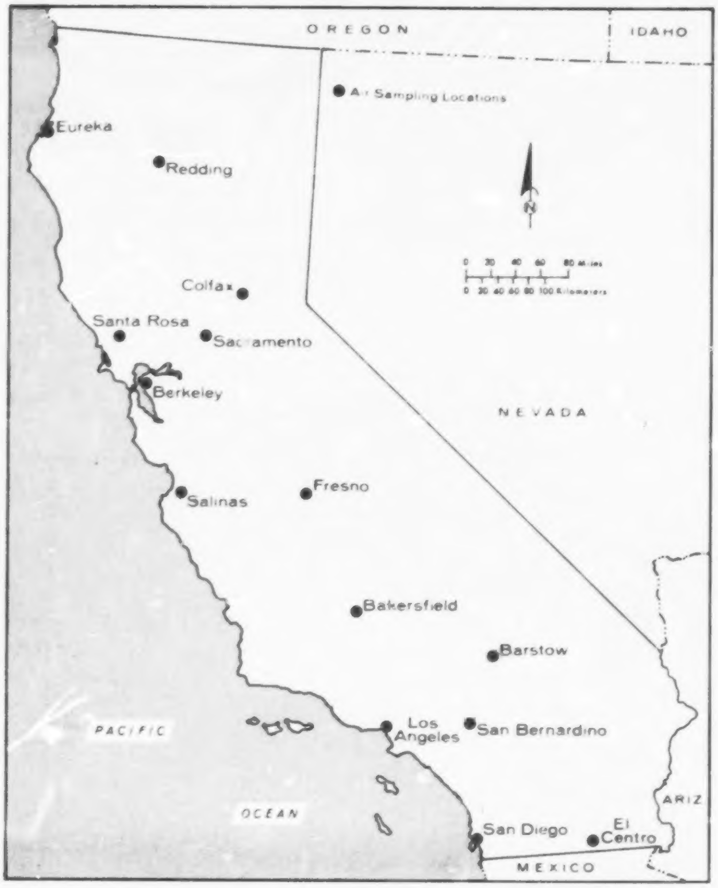
OREGON
IDAHO
Air Sampling Locations
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
Los Angeles
San Bernardino
PACIFIC
OCEAN
ARIZ
San Diego
El Centro
MEXICO
N
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers

Figure 4. California air sampling program stations

tinuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micrometer pore size, using a Gast air pump of about 2-cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity in air for January 1973. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air January 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	28	1.10	0.00	0.16
Barstow	20	.86	.02	.24
Berkeley	31	.10	.00	.04
Colfax	7	.07	.00	.02
El Centro	NA			
Eureka	23	.10	.00	.03
Fresno	31	.17	.01	.09
Los Angeles	31	.17	.00	.05
Redding	31	.14	.00	.03
Sacramento	31	.40	.00	.05
Salinas	31	1.00	.00	.12
San Bernardino	31	.46	.03	.13
San Diego	11	.06	.03	.04
Santa Rosa	31	.12	.00	.04
Summary	337	1.10	0.00	0.08

NA, no analysis.

REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

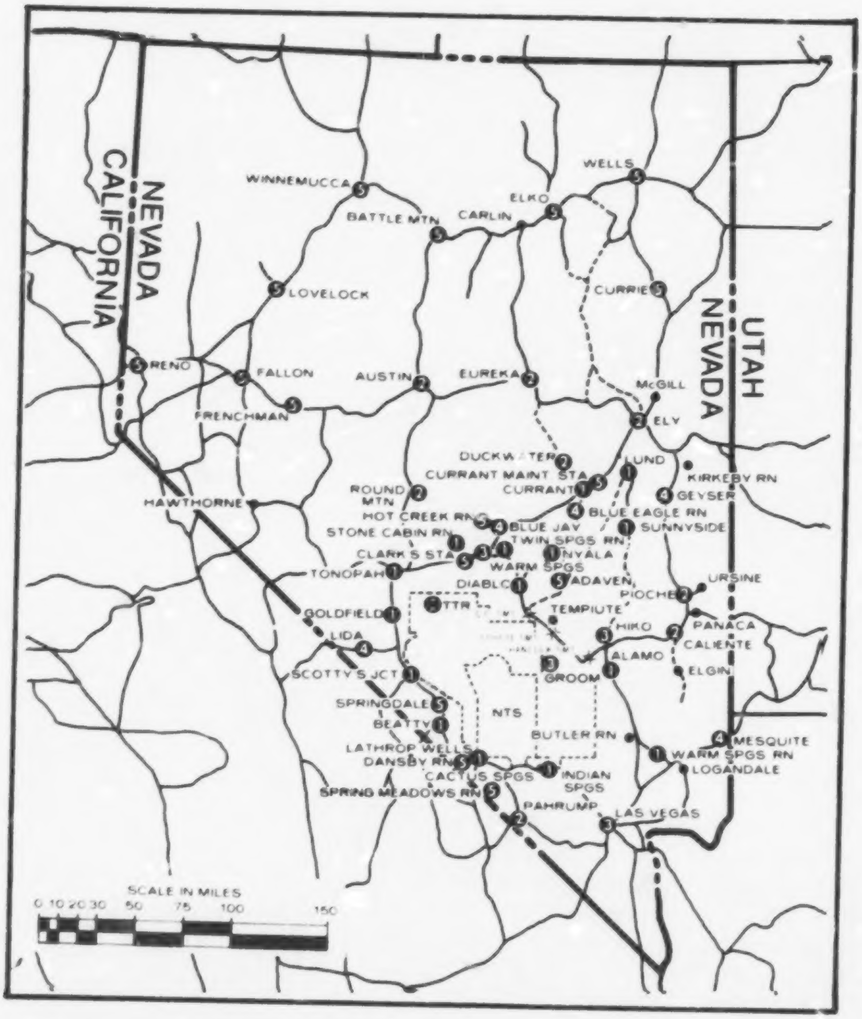
NEVADA
CALIFORNIA
UTAH
NEVADA
WINNEMUCCA 5
WELLS 5
ELKO 5
CARLIN
BATTLE MTN 5
LOVELOCK 5
CURRIE 5
RENO 5
FALLON 2
AUSTIN 2
EUREKA 2
McGILL
ELY 2
FRENCHMAN 5
DUCKWATER 2
LUND 1
KIRKEBY RN
CURRANT MAINT STA 5
CURRANT 1
ROUND MTN 2
GEYSER 4
HAWTHORNE
HOT CREEK RNG 5
BLUE EAGLE RN 4
BLUE JAV 4
SUNNYSIDE 1
STONE CABIN RN 1
TWIN SPGS RN 1
CLARK S STA 5 3
NYALA 1
WARM SPGS
TONOPAH 1
DIABLO 1
ADAVEN 5
URSINE
PIOCHE 2
TTR
TEMPIUTE
GOLDFIELD 1
HIKO 3
PANACA
LIDA 4
CALIENTE 2
ALAMO 1
SCOTTY'S JCT 1
GROOM 3
ELGIN
SPRINGDALE 5
NTS
BEATTY 1
BUTLER RN
MESQUITE 4
LATHROP WELLS 1
WARM SPGS RN 1
DANSBY RN 5
LOGANDALE
CACTUS SPGS
INDIAN SPGS 1
SPRING MEADOWS RN 5
PAHRUMP 2
LAS VEGAS 3
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. NERC-LV Air Surveillance Network stations in Nevada

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Air Surveillance Network, January 1973

National Environmental Research Center—Las Vegas,[1] Environmental Protection Agency

The Air Surveillance Network (ASN), operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 49 active and 73 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS) and by the AEC at any other designated testing sites.[2]

Previously, the network consisted of 104 active and 18 standby stations. The reduction in the number of active stations was implemented this year to economize operations due to the less frequent radioactive releases at the NTS and yet provide adequate coverage in case of a release.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

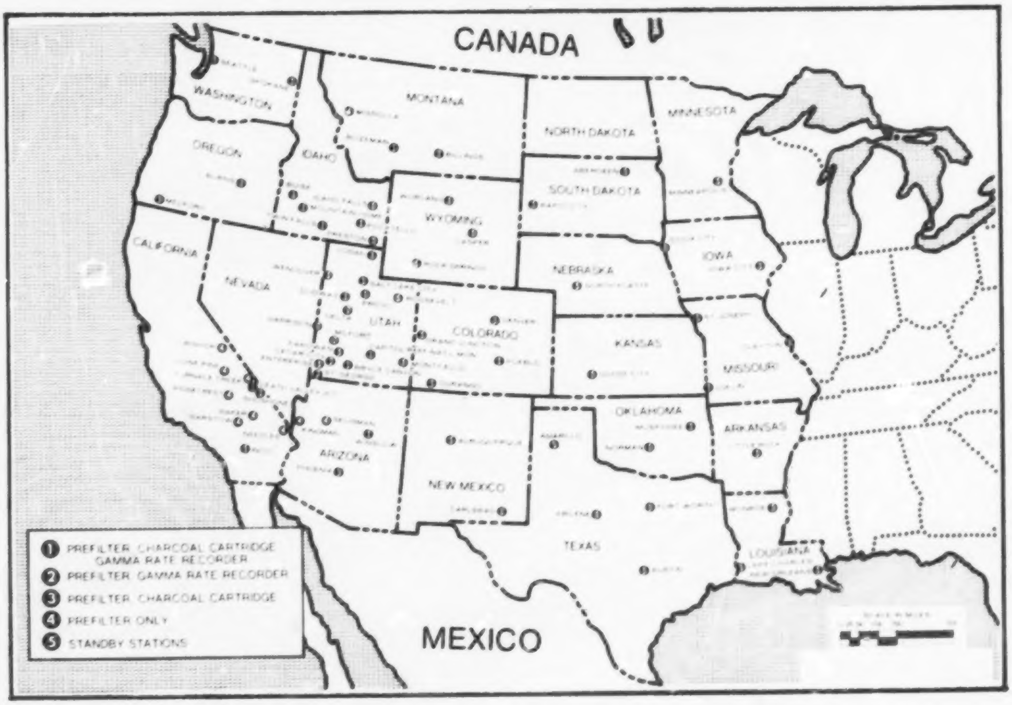
CANADA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
MEXICO
① PREFILTER CHARCOAL CARTRIDGE GAMMA RATE RECORDER
② PREFILTER GAMMA RATE RECORDER
③ PREFILTER CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS

Figure 2. NERC-LV Air Surveillance Network stations outside Nevada

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[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

Table 1. **Summary of gross beta radioactivity concentrations in air, January 1973**

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average [a]
Ariz:	Kingman	31	0.1	<0.1	0.1
	Seligman	31	<.1	<.1	.1
Calif:	Baker	27	.2	<.1	.1
	Barstow	31	.1	<.1	.1
	Bishop	31	<.1	<.1	.1
	Death Valley Junction	31	<.2	<.1	.1
	Furnace Creek	23	.1	<.1	.1
	Lone Pine	26	.1	<.1	.1
	Needles	19	.1	<.1	.1
	Ridgecrest	31	.1	<.1	.1
	Shoshone	31	<.1	<.1	.1
Nev:	Alamo	31	<.1	<.1	.1
	Austin	24	<.1	<.1	.1
	Beatty	30	.1	<.1	.1
	Blue Eagle Ranch (Currant)	31	<.2	<.1	.1
	Blue Jay	31	<.1	<.1	.1
	Caliente	31	<.1	<.1	.1
	Currant Ranch	31	<.2	<.1	.1
	Diablo	30	<.1	<.1	.1
	Duckwater	29	<.1	<.1	.1
	Ely	31	<.1	<.1	.1
	Eureka	31	.1	<.1	.1
	Fallini's Springs Ranch	31	.1	<.1	.1
	Geyser Maintenance Station	30	<.1	<.1	.1
	Goldfield	30	<.1	<.1	.1
	Groom Lake	20	.1	<.1	.1
	Hiko	31	.1	<.1	.1
	Indian Springs	31	.1	<.1	.1
	Las Vegas	20	.1	<.1	.1
	Lathrop Wells	31	<.1	<.1	.1
	Lida	31	<.1	<.1	.1
	Lund	28	<.1	<.1	.1
	Mesquite	31	.1	<.1	.1
	Nyala	31	.2	<.1	.1
	Pahrump	29	.1	<.1	.1
	Pioche	31	<.1	<.1	.1
	Round Mountain	31	<.1	<.1	.1
	Scotty's Junction	26	<.1	<.1	.1
	Stone Cabin Ranch	31	<.1	<.1	.1
	Sunnyside	8	<.1	<.1	.1
	Tonopah	31	<.1	<.1	.1
	Tonopah Test Range	26	<.1	<.1	.1
	Warm Springs	28	<.1	<.1	.1
	Warm Springs Ranch	31	.1	<.1	.1
Utah:	Cedar City	30	<.1	<.1	.1
	Delta	31	<.2	<.1	.1
	Garrison	31	<.1	<.1	.1
	Milford	31	<.1	<.1	.1
	St. George	31	.1	<.1	.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m^3 is reported as <0.1.

Results

Table 1 presents the monthly average gross beta concentrations in air for each of the network stations. The highest gross beta concentration within the network was 0.2 pCi/m^3 at Baker, Calif. and Nyala, Nev. The minimum reporting concentration for gross beta is 0.1 pCi/m^3. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06 pCi/m^3) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reporting level (0.1 pCi/m^3) are reported as <0.1 pCi/m^3. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during January.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Surface Air Sampling Program–80th Meridian Network[1] January-December 1970

Health and Safety Laboratory
Atomic Energy Commission

The Health and Safety Laboratory (HASL), began its Surface Air Sampling Program in January 1963, as a continuation of the 80th Meridian Program conducted by the U.S. Naval Research Laboratory. The objective of this program is to study the spatial and temporal distribution of nuclear weapons debris and lead in the surface air.

The basic network consists of a line of sites approximately along the 80th meridian extending from about 81° N. to 90° S. latitudes (figure 1). Since 1963, a number of sites have been added to investigate the possible effects of longitude, elevation, and proximity to coastlines; and from late 1965 through March 1969, samplers were placed on four Atlantic Ocean weather ships to extend the surface air study over the marine environment.

Sampling and analytical procedures

Approximately 1,400 cubic meters of ambient air per day are drawn through an 8-inch diameter microsorban filter for the land stations. For the ocean stations, about 2,200 cubic meters of air per day were filtered by an 8- by 10-inch microsorban filter. Each filter is changed on the 1st, 8th, 15th, and 22nd of the month or more frequently if the filter becomes clogged with debris suspended in the air.

The filters are returned to HASL at the end of each month and under normal conditions, composited into monthly samples for analysis. Until late 1969, the composited sample was first gamma counted and then sent to a contractor laboratory for radiochemical analysis. In the current program, each sample is split into equal aliquots, one for gamma counting and spectrometry and the other for radiochemistry and stable lead analysis. Hence, half of each sample is now being kept and stored for possible future work.

Daily pump pressure drop and temperature readings are also submitted to HASL along with the samples for the purpose of computing the volume of sampled air.

Gamma analysis

The gamma activity of half of the monthly composites are obtained with a 8- by 4-inch sodium iodide (Tl) crystal as soon as possible after receipt of the samples. The integrated response between 100 keV and 3.0 MeV is corrected by the average detection efficiency (35 percent) of the gamma photons present in fallout; and the total gamma activities are reported in units of photons per minute per 1,000 standard cubic meters.

Gamma spectra of the monthly composites are obtained using a lithium-drifted germanium diode (GeLi) system. Concentrations of the gamma emitting nuclides, beryllium-7, zirconium-95, cesium-137, and cerium-144 are determined by computer resolution of the spectra. Beginning in June 1970, all results from these nuclides, reported in the tables were obtained using this system.

Radiochemical analyses

The other halves of the monthly composites are sent to a contractor laboratory for radiochemical analyses.

There were no major weapon test series from the end of 1962 until May 1966. Consequently, only the longer-lived artificially produced radionuclides were present in the filters collected during this period, and emphasis was given to the determination of manganese-54, iron-55, strontium-90, cadmium-109, cesium-137, ce-

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[1] Summarized from "Fallout Program Quarterly Summary Report," HASL–268 (January 1, 1973) available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

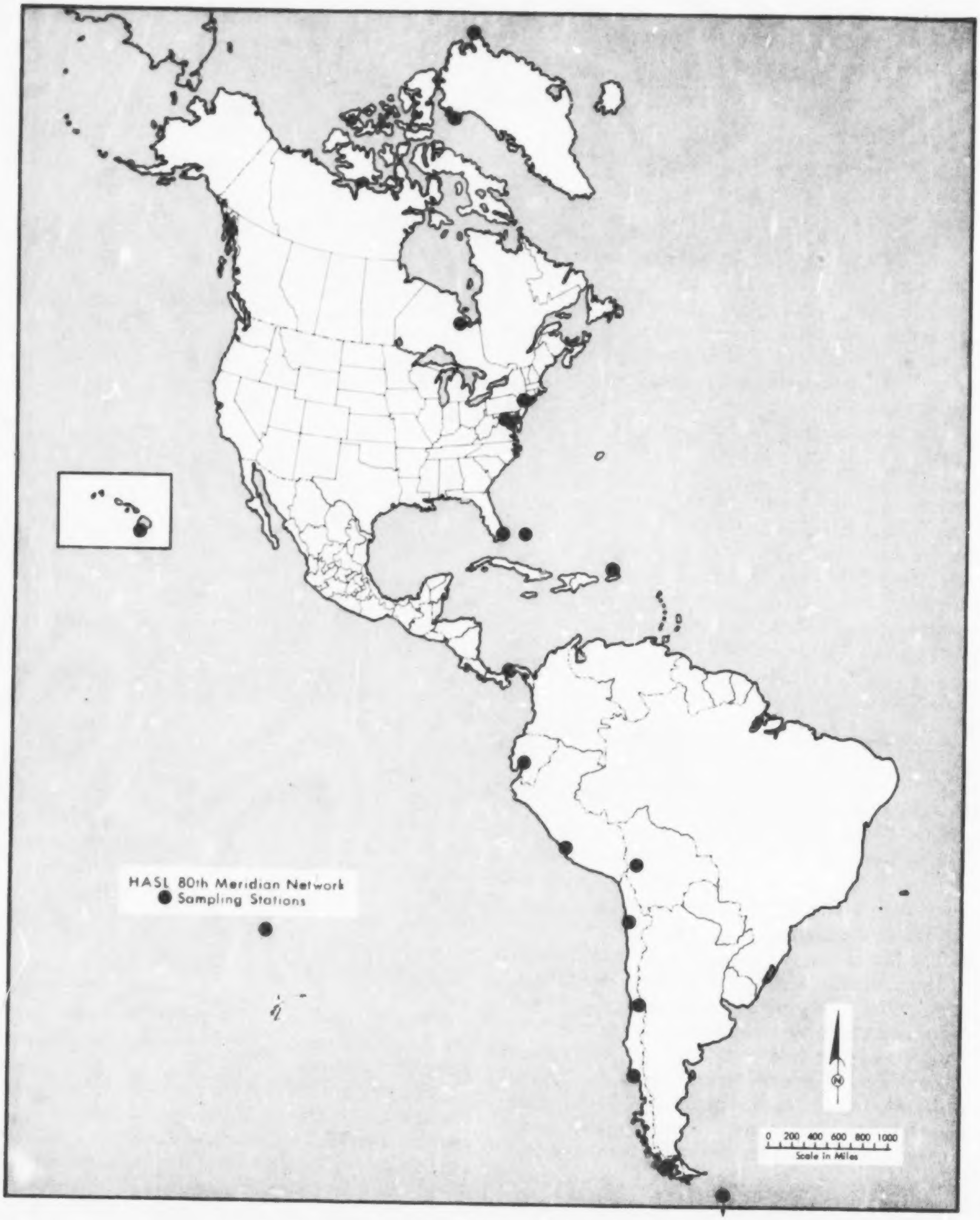
HASL 80th Meridian Network
● Sampling Stations
0 200 400 600 800 1000
Scale in Miles
N

Figure 1. HASL 80th Meridian Network sampling stations

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Table 1. Station location

Site		Latitude	Longitude (west)	Elevation (meters)
Greenland:	Nord	81° 40′N	17° 00′	250
	Thule	76° 36′N	68° 35′	259
Ontario:	Moosonee	51° 16′N	80° 30′	10
N.Y:	New York City	40° 48′N	73° 58′	38
Va:	Sterling	38° 58′N	77° 25′	76
Fla:	Miami	25° 49′N	80° 17′	4
Bahamas:	Bimini	25° 46′N	79° 22′	3
Hawaii:	Mauna Loa	19° 28′N	155° 36′	3,401
P.R:	San Juan	18° 26′N	66° 00′	10
Panama:	Balboa	8° 58′N	79° 34	23
Ecuador:	Guayaquil	2° 10′S	79° 52′	7
Peru:	Lima	12° 01′S	77° 08′	13
Bolivia:	Chacaltaya	16° 21′S	68° 07′	5,220
Chile:	Antofagasta	23° 37′S	70° 16′	31
	Isle de Pasqua	27° 10′S	109° 26′	41
	Santiago	33° 27′S	70° 42′	520
	Puerto Montt	41° 27′S	72° 57′	7
	Punta Arenas	53° 08′S	70° 53′	35
Antarctica [a]		62° 56′S 64° 49′S	60° 36′ 62° 52′	16 10
South Pole station		90° 00′S		2,800

[a] The Chilean Antarctic station has moved at least three times within an area of about 2° latitude and longitude. For simplicity, the individual station names were dropped and all data grouped under "Antarctica."

rium-144, plutonium-238, and plutonium-239. In samples collected after French or Chinese atmospheric weapons tests, additional short-lived nuclides were analyzed, such as strontium-89, zirconium-95, and cerium-141.

The longer-lived fission products and plutonium-239 concentrations should describe the general distribution in surface air in all previous nuclear weapon debris which was transferred from the lower stratosphere to the troposphere during the collection period of this report. Other tracer nuclides can be associated with debris from a single detonation or series of detonations. Manganese-54 and iron-55 were produced in large quantities in the 1961 and 1962 test series. Cadmium-109 was generated by the U.S. high altitude test over Johnston Island on July 9, 1962. While plutonium-238 is present in low concentrations in nuclear weapons debris, about 17,000 curies of plutonium-238 was disseminated at high altitude in the stratosphere on April 21, 1964 during the reentry burnup of a SNAP-9A power source.

As the levels of any of the radionuclides drop to below practical detection limits they are eliminated from the radiochemical program; thus cadmium-109 was not analyzed after the end of 1967.

In response to the growing concern over air pollution and in particular to the known hazard linked to stable lead, analysis for this element was added to the program.

Most of the analyses of surface air samples were carried out from July 1969 to the present by the Trapelo Division, Richmond, Calif.[2]

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[2] Trapelo Division West is now LFE-Environmental Analysis Laboratories.

Table 2. Strontium-89 concentrations in air, 1970[a]

Site		Concentration (fCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	—	—	—	—	—	—	—	—	1.40	260	24.5	—
	Thule	2.45	3.91	3.64	11.6	7.43	1.94	—	3.90	2.32	186	1.90	—
Ontario:	Moosonee	[b] 1.86	2.94	—	8.02	14.1	14.1	—	6.70	2.31	1.83	1.85	1.98
N.Y:	New York City	2.78	4.35	9.48	13.5	20.2	11.9	14.5	8.54	3.00	2.51	4.54	4.94
Va:	Sterling	1.69	4.68	7.06	17.9	24.3	22.0	11.7	7.66	2.66	2.09	5.02	5.49
Fla:	Miami	5.40	10.9	17.7	50.2	56.5	4.05	6.61	4.15	2.42	3.62	6.29	5.65
Bahamas:	Bimini	—	16.8	20.5	36.0	35.7	—	11.7	[b] .88	2.90	4.83	9.64	6.31
Hawaii:	Mauna Loa	10.4	27.7	54.2	54.4	35.1	19.7	18.0	6.21	7.15	12.5	6.89	3.72
P.R:	San Juan	2.51	17.1	8.17	28.6	17.5	13.2	9.03	7.03	3.43	4.27	5.67	3.60
Panama:	Balboa	5.25	5.45	—	15.9	10.7	6.88	4.39	—	4.53	—	—	—
Ecuador:	Guayaquil	—	—	[b] .42	—	[b] .18	17.5	52.5	28.0	25.7	10.1	6.9	4.66
Peru:	Lima	—	—	—	[b] .58	[b] .51	[b] .22	—	—	78.6	64.3	51.9	15.4
Bolivia:	Chacaltaya	—	—	—	(c)	32.2	—	—	—	214	114	63.1	11.8
Chile:	Antofagasta	—	—	—	—	—	—	—	128	83.4	53.1	36.5	22.1
	Santiago	—	—	[b] 1.08	[b] .28	39.9	10.0	61.3	—	54.4	34.0	6.5	23.3
	Puerto Montt	—	—	—	—	—	4.94	11.7	18.4	16.6	11.7	14.2	7.93
	Punta Arenas	—	—	[b] .50	[b] .22	[b] .19	1.34	4.57	4.60	6.38	4.82	6.45	3.23
Antarctica		—	—	—	—	—	—	—	(c)	(c)	(c)	[b] .42	(c)
South Pole station		—	—	—	—	(c)	[b] 3.27	[b] 5.92	4.62	7.72	8.56	5.48	15.1

[a] Errors are less than 20 percent except:
[b] Error between 20-100 percent;
[c] Error greater than 100 percent.
—, no data reported.

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Table 3. Strontium-90 concentrations in air, 1970[a]

Site		Concentration (fCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	—	—	—	—	—	—	—	—	1.36	1.18	1.18	—
	Thule	1.42	1.60	4.68	3.09	2.51	.72	—	1.85	2.14	1.10	.87	—
Ontario:	Moosonee	1.01	1.26	—	2.39	4.32	3.85	4.29	4.17	2.40	1.69	1.04	1.12
N.Y:	New York City	1.15	1.91	2.77	3.37	5.80	3.31	5.50	5.23	2.24	1.63	1.59	.99
Va:	Sterling	.98	1.88	2.05	3.35	5.92	6.25	4.78	5.16	2.17	1.40	1.38	.90
Fla:	Miami	1.47	3.03	2.71	7.95	11.20	4.11	2.58	1.97	.98	1.14	1.51	1.96
Bahamas:	Bimini	1.72	3.42	4.31	6.77	8.43	—	4.28	3.27	.86	.89	1.90	2.39
Hawaii:	Mauna Loa	1.43	3.68	7.00	7.48	7.39	5.15	4.42	2.05	2.37	.78	.95	.82
P.R:	San Juan	.60	1.37	2.69	5.55	3.63	3.42	3.89	3.45	1.17	.54	.91	1.18
Panama:	Balboa	.73	1.05	—	2.35	2.43	.58	.81	—	.21	—	—	—
Ecuador:	Guayaquil	.51	[b] .70	.28	—	.18	.38	.49	.45	.75	.46	.40	.42
Peru:	Lima	3.45	1.89	1.66	1.95	.89	1.02	—	—	2.42	3.25	3.14	1.36
Bolivia:	Chacaltaya	.72	.61	.81	.54	1.69	—	—	—	3.86	3.68	3.50	.82
Chile:	Antofagasta	4.99	1.42	1.15	—	—	—	—	2.12	2.74	2.87	2.27	2.03
	Isle de Pasqua	—	—	—	—	—	.75	—	—	—	—	—	—
	Santiago	2.46	(c)	1.73	1.20	.81	1.19	1.34	—	1.88	1.85	.44	2.40
	Puerto Montt	—	—	—	—	—	.46	.50	.63	.80	.77	1.18	.88
	Punta Arenas	.70	1.16	.60	.64	.39	.20	.39	.50	.37	.39	.51	.41
Antarctica		1.18	2.03	.89	1.20	1.12	.64	.75	.34	.50	.63	.57	.48
South Pole station		—	—	—	—	.44	.81	.85	.54	.69	.78	.62	1.79

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent;
(c) Error greater than 100 percent.
—, no data reported.

Table 4. Zirconium-95 concentrations in air, 1970[a]

Site		Concentration (fCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	—	—	—	—	—	—	—	—	7.59	5.53	[b] 4.29	[b] 6.40
	Thule	6.36	8.99	19.0	24.2	21.9	7.05	22.10	6.10	—	[b] .01	3.11	—
Ontario:	Moosonee	4.23	5.94	19.5	—	48.6	14.9	63.8	27.7	[illegible]	7.73	(c)	3.89
N.Y:	New York City	6.19	11.3	24.2	39.3	62.2	76.5	56.7	46.4	[illegible]	7.75	10.1	4.43
Va:	Sterling	5.01	10.8	18.2	—	70.1	86.4	55.4	38.3	13.9	9.25	11.8	[b] 2.98
Fla:	Miami	12.0	29.1	40.3	91.9	105	50.3	40.7	23.8	7.5	12.7	[illegible]	14.3
Bahamas:	Bimini	16.0	57.5	85.6	94.5	129	65.9	53.6	28.3	10.6	16.1	23.9	[b] [illegible]
Hawaii:	Mauna Loa	20.1	67.6	141	—	122	89.2	57.5	20.9	19.5	21.4	10.8	[illegible]
P.R:	San Juan	6.46	25.9	19.6	—	80.9	37.9	48.4	27.1	11.7	9.87	9.31	7.12
Panama:	Balboa	10.1	11.9	—	—	28.0	19.1	14.3	19.9	9.42	—	—	—
Ecuador:	Guayaquil	(c)	1.44	—	—	1.01	32.3	122	79.8	77.8	36.9	39.8	34.4
Peru:	Lima	4.66	1.44	—	[b] 1.19	[b] 1.23	85.5	897	361	244	215	117	84.3
Bolivia:	Chacaltaya	2.60	.92	.61	—	45.0	785	415	813	392	220	110	—
Chile:	Antofagasta	4.94	[b] 1.05	.85	—	—	—	525	350	211	170	69.7	55.8
	Isle de Pasqua	—	—	—	—	—	[b] 380	—	—	—	—	—	—
	Santiago	[b] 2.01	2.38	[b] 1.14	(c)	71.8	16.2	139	107	130	138	70.7	61.9
	Puerto Montt	—	—	—	—	—	9.35	25.4	29.7	—	27.6	4.44	17.3
	Punta Arenas	[b] 1.32	.99	[b] .32	—	(c)	3.08	9.31	9.65	—	13.0	14.9	8.63
Antarctica		—	—	—	—	—	—	—	—	—	[b] 109	[b] 98.7	—
South Pole station		—	—	—	—	—	—	[b] .00	—	14.8	18.4	12.2	13.1

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent;
(c) Error greater than 100 percent.
—, no data reported.

Results

The radioactivity concentrations in surface air during January–December 1970 are presented in tables 2 through 8. The sites are listed according to latitude beginning with the most northern site at Nord, Greenland (table 1).

The concentrations are reported at the midpoint of the collection month for the plutonium isotopes and the fission products.

One standard deviation of the counting error for these data is always less than ±20 percent unless otherwise indicated.

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Table 5. Cesium-137 concentrations in air, 1970[a]

Site		Concentration (fCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	—	—	—	—	—	—	—	—	2.66	8.42	2.81	4.29
	Thule	2.31	2.58	3.91	4.62	4.04	1.28	4.24	3.50	—	5.28	1.51	—
Ontario:	Moosonee	1.46	2.24	4.22	—	8.40	6.13	12.0	7.49	4.56	2.97	1.91	2.33
N.Y:	New York City	1.98	2.84	4.46	5.16	8.15	11.9	10.7	11.8	5.33	3.18	2.48	1.74
Va:	Sterling	.80	2.87	3.13	—	9.36	12.1	10.3	9.45	4.40	3.11	2.34	2.05
Fla:	Miami	2.00	4.83	5.05	9.78	11.4	8.34	7.39	5.60	1.97	2.78	3.43	4.84
Bahamas:	Bimini	3.17	8.73	7.10	12.2	14.6	9.76	9.68	6.44	2.49	3.14	3.92	5.07
Hawaii:	Mauna Loa	2.24	6.78	11.1	—	13.8	11.5	9.16	4.03	4.66	1.15	1.40	1.92
P.R:	San Juan	.87	3.56	4.37	—	8.94	5.57	8.93	6.68	2.61	1.13	1.45	2.01
Panama:	Balboa	.85	1.66	—	—	3.64	1.43	1.90	1.37	[b] .40	—	—	—
Ecuador:	Guayaquil	.92	.95	.64	—	.33	.78	1.87	.91	1.89	1.37	1.70	2.08
Peru:	Lima	4.72	2.63	2.46	3.18	1.34	2.17	11.8	5.20	6.15	8.53	5.90	5.02
Bolivia:	Chacaltaya	.84	.57	.49	—	2.54	7.38	5.68	7.82	6.31	6.03	4.30	—
Chile:	Antofagasta	6.65	2.56	1.79	—	—	—	7.43	4.88	5.04	6.81	3.70	3.19
	Isle de Pasqua	—	—	—	—	—	1.21	—	—	—	—	—	—
	Santiago	4.16	4.13	2.88	2.21	2.33	[b] .99	3.32	3.24	4.11	5.67	4.00	4.50
	Puerto Montt	—	—	—	—	—	.98	1.03	.98	—	1.22	3.43	1.38
	Punta Arenas	1.04	1.48	.94	—	.39	.44	.54	.58	—	.67	1.00	.75
Antarctica		3.65	1.48	1.32	1.39	1.22	1.72	.75	.46	.79	.81	.57	.70
South Pole station		—	—	—	—	—	1.28	[b] 1.95	.75	1.04	1.13	1.33	1.41

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent;
[c] Error greater than 100 percent.
—, no data reported.

Table 6. Cerium-144 concentrations in air, 1970[a]

Site		Concentration (fCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	—	—	—	—	—	—	—	—	24.9	21.4	16.7	28.2
	Thule	19.7	21.3	38.6	45.1	47.7	12.7	46.6	39.2	—	14.9	12.7	—
Ontario:	Moosonee	14.2	19.5	39.2	—	77.3	99.3	123	71.7	41.8	22.8	—	—
N.Y:	New York City	18.9	28.6	38.1	57.4	105	132	115	117	47.0	29.2	22.0	14.6
Va:	Sterling	13.7	25.9	29.9	—	94.2	148	108	96.4	43.1	29.4	20.0	14.0
Fla:	Miami	23.4	49.2	56.5	144	165	80.0	82.8	54.6	18.5	25.9	26.5	34.9
Bahamas:	Bimini	33.2	90.4	85.6	135	203	107	102	68.7	21.9	28.8	37.7	37.3
Hawaii	Mauna Loa	25.2	75.8	109	—	157	133	98.4	38.7	43.1	10.4	13.7	14.6
P.R:	San Juan	9.67	37.6	48.0	—	106	62.1	97.3	62.6	20.9	10.6	11.1	15.1
Panama:	Balboa	12.3	16.1	—	—	39.4	19.1	20.1	13.5	3.81	—	—	—
Ecuador:	Guayaquil	7.76	7.98	5.16	—	3.12	8.19	28.2	20.6	25.3	17.2	18.0	26.6
Peru:	Lima	36.3	20.4	18.0	15.8	6.57	23.2	189	88.3	82.1	103	67.0	63.4
Bolivia:	Chacaltaya	6.27	5.75	3.23	—	17.8	152	108	176	108	90.4	57.2	—
Chile:	Antofagasta	46.7	12.5	14.5	—	—	—	126	90.1	76.2	84.7	43.8	39.8
	Isle de Pasqua	—	—	—	—	—	11.7	—	—	—	—	—	—
	Santiago	27.8	38.9	20.6	12.2	20.9	6.37	38.3	36.3	41.7	70.2	45.6	51.1
	Puerto Montt	—	—	—	—	—	5.70	8.32	10.3	—	14.6	20.5	15.1
	Punta Arenas	7.13	10.1	6.58	—	2.33	1.08	4.44	4.52	—	4.26	10.0	.87
Antarctica		[b] 3.96	—	[b] 8.24	[b] 5.23	2.59	1.16	2.22	[b] 1.94	[b] 7.12	3.97	4.23	5.68
South Pole station		—	—	—	—	—	6.09	[b] 8.97	4.50	8.09	9.54	9.21	12.1

[a] Errors are less than 20 percent except:
[b] Error between 20-100 percent;
[c] Error greater than 100 percent.
—, no data reported.

Table 7. Plutonium-238 concentrations in air, 1970[a]

Site		Concentration (aCi/m^3)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	—	—	—	—	—	—	—	—	[b] 2.64	[b] 0.99	[b] 2.29	—
	Thule	[b] 5.17	5.50	7.53	[b] 9.17	8.63	[b] 0.92	[b] 4.58	[b] 3.65	[b] 3.49	[b] 2.46	[b] 2.35	—
Ontario:	Moosonee	[b] 4.64	6.64	11.2	[b] 12.7	9.73	9.44	9.05	[b] 4.55	[b] 4.05	[b] 1.69	[b] 3.47	[b] 0.97
N.Y:	New York City	4.73	10.5	9.08	12.5	12.8	11.7	9.51	10.9	12.2	6.82	4.72	—
Va:	Sterling	[b] 3.86	8.32	9.11	10.1	11.4	10.3	7.34	12.0	[b] 2.42	[b] 3.17	7.76	[b] 2.39
Fla:	Miami	[b] 7.54	13.8	9.33	15.9	15.7	9.94	[b] 4.78	[b] 4.32	[b] 1.37	[b] 3.60	[b] 2.68	[b] 3.45
Bahamas:	Bimini	[b] 5.42	19.8	[b] 10.6	21.9	22.1	—	6.66	[b] 6.41	[b] 2.45	[b] 1.86	[b] 5.57	[b] 8.58
Hawaii:	Mauna Loa	[b] 5.67	11.0	21.1	[b] 11.9	12.5	[b] 7.92	[b] 6.85	([c])	[b] 3.43	[b] 3.68	31.9	[b] 3.56
P.R:	San Juan	[b] 2.90	11.3	8.67	[b] 12.6	11.0	[b] 5.54	[b] 6.43	[b] 7.92	[b] 1.73	[b] 1.32	[b] 2.05	[b] 5.64
Panama:	Balboa	[b] 6.08	[b] 5.[illegible]	—	8.52	[b] 7.98	[b] 1.61	([c])	—	[b] 4.07	—	—	—
Ecuador:	Guayaquil	7.26	[b] [illegible]	[b] 5.09	—	([c])	[b] 2.22	30.2	[b] 4.85	15.0	5.84	6.49	9.33
Peru	Lima	24.0	16.0	17.8	[b] 14.4	[b] 5.96	10.3	—	—	44.6	34.5	20.9	14.6
Bolivia:	Chacaltaya	[b] 5.56	[b] 3.83	[b] 2.75	([c])	19.5	—	—	—	36.9	17.5	14.0	[b] 2.84
Chile:	Antofagasta	[b] 22.2	[b] 10.4	12.8	—	—	—	—	24.2	47.2	32.9	13.2	[b] 8.00
	Isle de Pasqua	—	—	—	—	—	6.53	—	—	—	—	—	—
	Santiago	[b] 76.3	24.6	20.2	104	11.1	31.4	18.9	—	23.4	22.2	10.6	15.2
	Puerto Montt	—	—	—	—	—	[b] 5.24	[b] 3.61	[b] 4.88	9.11	8.18	([c])	6.75
	Punta Arenas	[b] 5.65	[b] 26.2	([c])	6.45	[b] 2.79	—	[b] 3.20	[b] 2.45	[b] 3.52	[b] 2.79	[b] 3.03	[b] 2.55
Antarctica		[b] 6.76	[b] 2.77	[b] 1.08	[b] 1.37	([c])	([c])	[b] 1.41	([c])	[b] .99	[b] 3.15	([c])	([c])
South Pole station		—	—	—	—	[b] 3.94	9.27	[b] 12.9	[b] 4.21	5.99	9.79	[b] 4.05	4.81

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent;
[c] Error greater than 100 percent.
—, no data reported.

Table 8. Plutonium-239 concentrations in air, 1970[a]

Site		Concentration (aCi/m^3)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	—	—	—	—	—	—	—	—	22.7	23.0	19.9	—
	Thule	36.0	31.4	56.0	61.3	54.0	14.3	40.7	33.6	34.9	19.2	14.5	—
Ontario:	Moosonee	22.2	26.9	59.2	51.9	74.7	94.4	112	72.3	49.9	31.1	17.4	21.0
N.Y:	New York City	28.2	44.8	48.3	65.2	99.9	125	118	111	51.8	36.0	26.2	—
Va:	Sterling	18.0	36.4	41.9	60.0	104	113	88.4	90.1	44.6	25.5	23.9	13.2
Fla:	Miami	28.2	65.7	61.0	119	147	80.3	65.6	46.9	19.5	39.0	34.3	43.7
Bahamas:	Bimini	45.8	123	81.7	139	185	—	83.2	66.9	26.1	32.7	46.3	53.6
Hawaii:	Mauna Loa	25.8	76.6	140	133	126	115	83.3	36.9	47.0	[b] 9.05	15.4	13.7
P.R:	San Juan	14.7	47.8	52.3	120	69.3	63.4	115	71.6	32.0	15.0	14.9	19.8
Panama:	Balboa	14.7	22.3	—	48.8	48.1	15.8	[b] 18.9	—	[b] 4.67	—	—	—
Ecuador	Guayaquil	6.28	10.3	[b] 9.49	—	([c])	17.8	200	24.3	30.6	17.5	23.4	30.2
Peru:	Lima	48.7	29.6	54.1	[b] 27.6	7.41	67.1	—	—	122	94.0	69.1	72.8
Bolivia:	Chacaltaya	[b] 6.67	[b] 11.5	5.79	([c])	97.7	—	—	—	106	71.7	54.8	[b] 14.8
Chile:	Antofagasta	50.9	26.5	23.0	—	—	—	—	83.4	126	99.2	44.3	42.0
	Isle de Pasqua	—	—	—	—	—	19.7	—	—	—	—	—	—
	Santiago	[b] 51.0	87.3	23.0	[b] 23.7	100	236	82.8	—	59.5	59.7	42.1	47.7
	Puerto Montt	—	—	—	—	—	11.3	13.9	15.0	21.4	18.3	[b] 27.2	18.4
	Punta Arenas	[b] 12.7	[b] 17.5	[b] 9.54	10.4	4.34	4.49	10.5	7.18	9.28	8.7	11.7	[b] 3.68
Antarctica		15.5	32.0	14.7	18.8	15.90	13.9	9.21	[b] 8.56	6.08	[b] 6.85	9.6	9.08
South Pole station		—	—	—	—	[b] 6.39	12.9	[b] 9.11	10.3	11.5	16.2	10.3	16.2

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent;
[c] Error greater than 100 percent.
—, no data reported.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1969	February 1972

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Offsite Surveillance Around the Nevada Test Site, January-June 1970[1]

National Environmental Research Center-
Las Vegas,[2] *and*
Nevada Operations Office, AEC

Under a Memorandum of Understanding with the U.S. Atomic Energy Commission, the National Environmental Research Center-Las Vegas (NERC-LV), conducted its continuing program of radiological surveillance for the Nevada Test Site (NTS) and other areas designated by the AEC from January through June 1970. During this period, 24 announced underground nuclear tests were conducted at the NTS. Offsite radiological surveillance was also provided for the post-event ventilation of the entry tunnel for the "Mint Leaf Event" at the NTS and for "Humid Water," a nonnuclear event conducted near Hattiesburg, Miss.

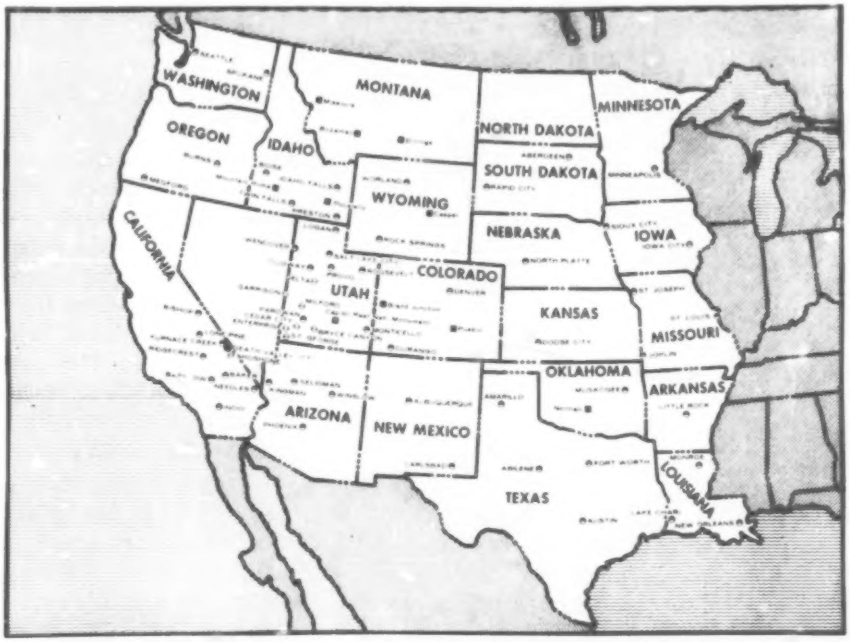
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
CALIFORNIA
COLORADO
UTAH
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
ARIZONA
NEW MEXICO
TEXAS
LOUISIANA

Figure 1. Air sampling and gamma-rate recorder network stations outside Nevada

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[1] This article is a summary of report No. SWRHL-108r, "Off-Site Surveillance Activities of the Southwestern Radiological Health Laboratory from January through June 1970."

[2] Formerly Southwestern Radiological Health Laboratory, U.S. Department of Health, Education, and Welfare, Public Health Service, Bureau of Radiological Health.

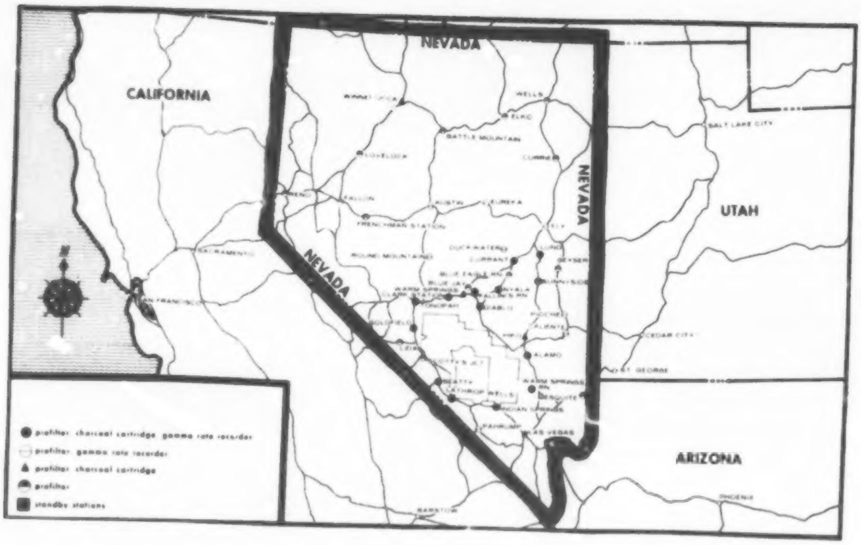
NEVADA
CALIFORNIA
UTAH
ARIZONA
SALT LAKE CITY
WELLS
ELKO
BATTLE MOUNTAIN
LOVELOCK
FALLON
AUSTIN
EUREKA
FRENCHMAN STATION
ROUND MOUNTAIN
ELY
SACRAMENTO
SAN FRANCISCO
CEDAR CITY
ST. GEORGE
BEATTY
LATHROP WELLS
INDIAN SPRINGS
PAHRUMP
LAS VEGAS
ALAMO
BARSTOW
PHOENIX
● prefilter, charcoal cartridge, gamma rate recorder
○ prefilter, gamma rate recorder
▲ prefilter, charcoal cartridge
◓ prefilter
■ standby stations

Figure 2. Air sampling and gamma-rate network stations in Nevada

Operational procedures

Before each event, mobile ground monitors were positioned downwind. If a release occurred, they conducted a monitoring program directed from a control point located on the NTS. In addition to the routine sampling and monitoring provided within about a 300-mile radius of the NTS, surveillance was extended as necessary to provide adequate coverage. Measurements were made periodically until activity levels returned to background.

Each monitor was equipped with two Eberline E-500B survey meters, a Baird-Atomic NE-148A Scintillator and a Victoreen Radector, Model No. AGB-50B-SR. Eberline RM-11 gamma-rate recorders at fixed locations (figure 1) documented cloud passage. An Air Force U-3A aircraft was used for aerial cloud tracking and two NERC-LV Turbo-Beech aircraft provided additional long-range tracking and sampling.

The NERC-LV Air Surveillance Network (ASN) consisted of 102 stations operating in every State west of the Mississippi River except Montana and North Dakota (figures 1 and 2). The air sampler used in the ASN was a Gelman "Tempest" which consisted of a Gast Model 1550 vacuum pump driven by an electric motor. For filter media, a 4-inch-diameter Gelman type E glass-fiber filter was used at each sampling station; and at 20 stations close to the NTS, an MSA charcoal cartridge was also used behind each filter. By telephone request, charcoal cartridges were added to other selected stations as requested.

The routine milk sampling program from both commercial and private producers continued. During the 6-month period, 209 samples were collected from about 45 sources which were sampled on a monthly basis.

Vegetation samples were collected after known releases of radioactivity to help delineate the fallout pattern. Samples of cow feed were collected at most locations where special milk samples were taken. During this period, 566 samples of potable and nonpotable water were collected from about 98 locations.

During the latter part of this period, the use of film badges was discontinued and only thermoluminescent dosimeters (TLD) were used for both personnel and fixed station dosimetry. Sixty-two residents in the offsite area wore TLD's and three TLD's were placed at each of the 102 permanent stations.

A NERC-LV medical officer was available to investigate reports of injuries alleged to be a result of the test series and to maintain liaison with local physicians. No injuries were reported. Veterinarian services were also provided to conduct wildlife and domestic livestock investigations. Community information centers were established in towns around the NTS for one event involving a device in the megaton range, to disseminate information on the event schedule and possible hazards. A number of offsite residents participated in the sampling program. All routine air sampling stations except those in Las Vegas were operated by local residents.

Analytical procedures

Samples were returned to the NERC-LV for radiological analysis. Air sample particulate filters were counted for beta radioactivity in a Beckman Widebeta, low-background proportional counter system. Selected particulate filters, all charcoal cartridges, and water and milk samples were analyzed for gamma-emitting radionuclides using a 4- by 4-inch NaI(Tl) crystal coupled to a TMC Model 404C gamma pulse height analyzer. The lower limit of detection for gamma emitters in air, milk, and water samples was 10 $\mathrm{pCi/m^3}$, 20 pCi/liter, and 20 pCi/liter, respectively, at the time of count. Gamma spectra were evaluated using a matrix technique which allowed for the simultaneous determination of eight nuclides.

Results

Radioactive material was released offsite following one underground nuclear test the "Snubber Event," on April 21, 1970.

The highest level of radioactivity attributed to the "Snubber Event" was about 0.6 mR/h above background measured at Coyote Summit, an unpopulated location. The net gamma exposure from the integration of readings with time at this location was 0.15 mR. No exposure levels above normal background were detected by TLD's. Special samples of vegetation, soil, snow, drinking water, cow feed and milk were collected after this event, including 40 milk samples from eight standby milk stations in Utah and 34 from seven standby milk stations in Arizona. Event-related radioactivity was found only on snow samples collected at two locations and on air samples obtained at nine locations. A snow sample collected at Sunnyside on the day following the event contained 500 pCi/liter of iodine-133, and 690 pCi/liter of iodine-135. The analytical results for air samples with activity above background levels are shown in table 1.

Table 1. Five highest iodine-133 and iodine-135 results and associated gross beta results from air sample media extrapolated to end of collection period (combined particulate and charcoal filters)
Snubber Event, April 21, 1970

Location azimuth-distance from CP-1	Time on off	Date on off (1970)	Average concentrations during collection period and integrated concentrations					
			Gross beta		Iodine-133		Iodine-135	
			$\frac{\mathrm{pCi}}{\mathrm{m^3}}$	$\frac{\mu\mathrm{Ci\text{-}s}}{\mathrm{m^3}}$	$\frac{\mathrm{pCi}}{\mathrm{m^3}}$	$\frac{\mu\mathrm{Ci\text{-}s}}{\mathrm{m^3}}$	$\frac{\mathrm{pCi}}{\mathrm{m^3}}$	$\frac{\mu\mathrm{Ci\text{-}s}}{\mathrm{m^3}}$
Coyote Summit, Nev.,[a] 25°, 49 miles	0835 1440	4/21 4/21	6.0	0.13	87	1.9	300	6.6
Coyote Summit, Nev., Koyne's Mills, 23°, 52 miles	0833 1440	4/21 4/21	<2.7	<.06	36	.79	86	1.9
Currant Maintenance Station, Nev., 16° 135 miles	0655 0745	4/21 4/21	.5	.05	5.6	.51	ND	ND
Hancock Summit, Nev.,[a] 48°, 49 miles	0825 1449	4/21 4/21	<2.5	<.06	12	.28	4.5	.10
Nyala, Nev., 11°, 91 miles	0800 0800	4/21 4/22	<.2	<.02	3.3	.28	ND	ND

[a] Temporary stations.
ND, nondetectable.

A controlled release of radioactivity was conducted on the day following the "Mint Leaf Event" of May 5. The entry tunnel was ventilated on May 6, 1970, to enable workers to reenter the area. A portable air sampler operating at the Valley Road-Highway 25 junction (near Koyne's Mill) indicated a concentration of 700 pCi/m^3 of xenon-135, assuming 100-percent collection efficiency for xenon on a charcoal cartridge. Although it is known that the collection efficiency of activated charcoal for xenon is less than 100 percent, uncertainties regarding the efficiency of this specific sampler under the conditions it was operating preclude providing a more exact concentration value. This was the only indication of activity measured offsite.

Conclusions

Environmental radiation surveillance during this period indicated that no individual in the offsite area received an exposure resulting from nuclear testing activities in Nevada which exceeded the guides established by the AEC and/or the Federal Radiation Council. No measurable whole body exposures were observed and environmental sampling data indicated that the maximum hypothetical radiation dose to an infant thyroid (2 grams) was less than 1 mrem as a result of inhalation, with no contribution from ingestion.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radio activity data follow for Argonne National Laboratory.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. Argonne National Laboratory[2]
January-December 1971

University of Chicago
Lemont, Ill.

Argonne National Laboratory (Illinois site) is located on a 3,700-acre site in DuPage County, 27 miles southwest of downtown Chicago. It lies south of Interstate Highway 55 and west of Illinois Highway 83. The terrain is rolling, partially-wooded, former prairie and farmland. The grounds contain a number of ponds and small streams, the principal one being Sawmill Creek, which runs through the site in a southerly direction and enters the Des Plaines River about 1.3 miles southeast of the center of the site. The land is drained primarily by Sawmill Creek, although the extreme southern portion drains directly into the Des Plaines River. This river flows southwest until it joins the Kankakee River about 30 miles southwest of the laboratory to form the Illinois River.

Argonne is a multidisciplinary research and development laboratory with two principal objectives: it carries out a broad program of basic research activities, and it serves as an important center for the design and development of nuclear reactors. Most of the basic research is concerned with the application of radiation as a tool in the physical and life sciences. The reactor effort is now devoted largely to development of the liquid-metal-cooled fast-breeder power reactor. Almost all of the work at the laboratory is of an unclassified nature and deals with peacetime applications of nuclear energy.

The principal nuclear facilities at the laboratory are a 5 MW heavy-water cooled and moderated general-purpose research reactor (CP–5) fueled with fully-enriched uranium; a 200 kW light-water cooled and moderated biological research reactor (JANUS) fueled with fully-enriched uranium; a 12.5 GeV proton accelerator, the Zero Gradient Synchrotron (ZGS); two critical assemblies, or zero power reactors (ZPR–6 and –9), that are fueled at various times with plutonium, uranium, or a combination of the two; a 60-inch cyclotron; several Van de Graaff accelerators; a fuel fabrication facility designed for plutonium usage; and several laboratories designed for work with irradiated fuel elements and with multicuries quantities of the heavy element alpha emitters.

The radioactivity of the environment was determined by measuring the concentrations of radioactive nuclides in naturally-occurring materials and by measuring the external penetrating radiation dose. Sample collections and measurements were made both on and off the site for comparison purposes. Since radioactivity is usually spread by air and water, the sample collection program has concentrated on these media. In addition, soil, plants, milk, precipitation, animals, and material from the beds of lakes and streams were also collected and analyzed. The results included in this report are those that are pertinent to the evaluation of Argonne's contribution to the environmental radioactivity and to the differentiation of Argonne activity from fallout and other sources.

When a nuclide was not detected, the result is given as less than (<) the minimum amount detectable (detection limit) by the analytical method used. Averages including individual results that were less than the detection limit were calculated by one of the following two methods. If the bulk of the individual results was less than the detection limit, the average was calculated with the assumption that such results were equal to the detection limit, and the resulting average value is expressed as less than the computed average. If only a small fraction of the individual results were less than the detection limit, the average was calculated with the assumption that such results were actually one-half of the detection limit, and the average is given as a positive value. The averages that are obtained by using these two methods under the conditions indicated are believed to give an adequate picture of the true average activity at locations where the activity not only varied greatly, but at times was not detectable.

Average values are usually accompanied by

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[2] Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites—Calendar Year 1971."

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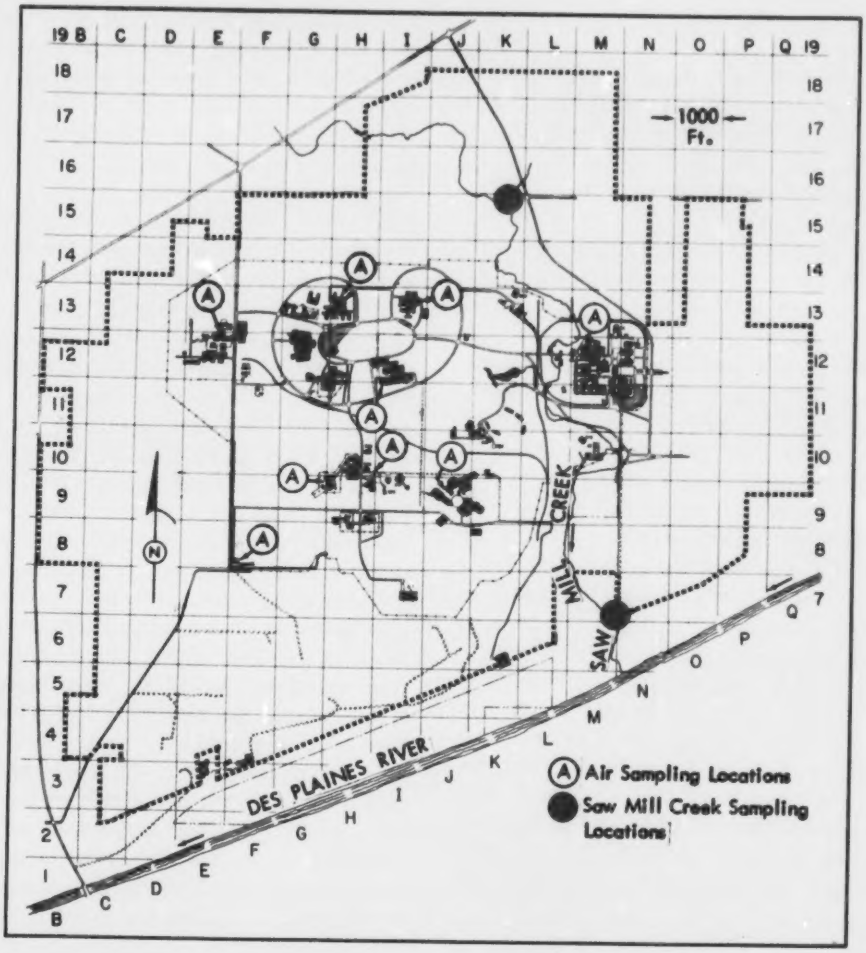
a plus-or-minus (±) limit value. This value is the 95-percent confidence limit calculated from the standard deviation of the average and is a measure of the range in the activities encountered at that location. It does not represent the conventional error in the average of repeated measurements on the same or identical samples. Since many of the variations that occur in environmental radioactivity are not random but occur for specific reasons (e.g., nuclear testing), samples collected from the same location at different times are not replicates. The more random the variation in activity at a particular location, the closer the confidence limits will represent the actual distribution of values at that location. The averages and confidence limits should be interpreted with this in mind. When a ± figure accompanies an individual result in this report, it represents the statistical counting error at the 95-percent confidence level.

Where environmental quality standards have been established, the measured concentration or radiation dose is compared with the standard as a means of assessing its hazard. Unless otherwise specified, the standards used in this report are those given in AEC Manual Chapter 0524.



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1000 Ft.
N
SAW MILL CREEK
DES PLAINES RIVER
A Air Sampling Locations
Saw Mill Creek Sampling Locations

Figure 1. Onsite sampling locations at Argonne National Laboratory

Radioactivity in air

The radioactivity of particulate matter in air was determined by drawing air through filter paper at a known rate and measuring the radioactivity of the particles collected by the paper. Samples were collected continuously, except for occasional equipment failures, at nine locations on the Argonne site and at six locations off the site. The sampling locations are shown in figures 1 and 2. At one location on the site, the filter paper was changed daily, at all other locations, the filter papers were changed at weekly intervals. The daily samples record short-term changes in radioactivity, while the weekly samples are used to compare onsite and offsite activities. Higher activities on the site are indicative of radioactivity released by Argonne if the differences are greater than the error in sampling and counting. This error is between 5 and 20 percent for most results, but approaches 100 percent at the detection limit.

The total alpha and beta radioactivities in the weekly samples are given in table 1; the average concentrations of a number of gamma-ray emitters, as determined by gamma-ray spectrometry performed on composite weekly samples, are given in table 2. The alpha and beta radioactivities were measured in low-background gas-flow proportional counters, and the counting efficiencies used to convert counting rates to disintegration rates were those measured for radon decay products on filter paper. The gamma-ray measurements were

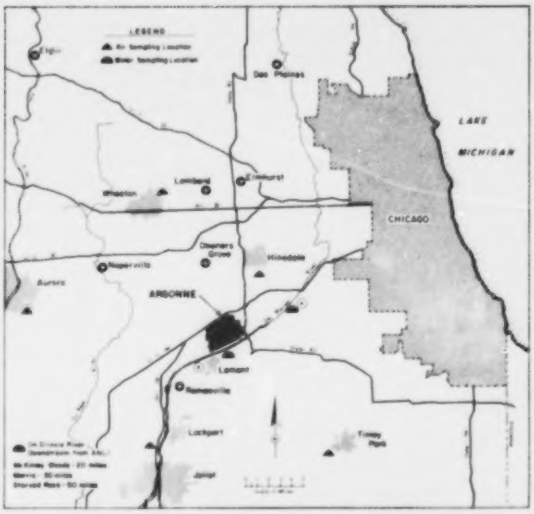

Figure 2. Locations of Argonne National Laboratory (including some offsite sampling locations)

Table 1. Alpha and beta radioactivity in air-filter samples,[a] Argonne National Laboratory January–December 1971

Period	Location	Number of samples	Alpha radioactivity (fCi/m³)			Beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average	Maximum	Minimum	Average
January	Onsite	26	5.1	2.2	3.4	0.14	0.068	0.097
	Offsite	28	4.9	1.8	3.3	.13	.070	.097
February	Onsite	26	3.7	.6	2.1	.16	.072	.12
	Offsite	24	4.3	1.3	2.5	.18	.072	.12
March	Onsite	31	5.4	.8	2.2	.38	.099	.20
	Offsite	26	4.7	1.2	2.2	.38	.12	.22
April	Onsite	30	9.0	1.8	4.9	.75	.14	.46
	Offsite	26	7.0	1.9	4.1	.76	.20	.47
May	Onsite	32	6.4	2.0	3.7	1.2	.45	.76
	Offsite	22	6.1	1.7	3.6	.98	.50	.77
June	Onsite	34	8.1	1.2	4.0	1.0	.42	.64
	Offsite	25	5.5	1.7	3.6	.80	.49	.64
July	Onsite	36	6.4	.8	3.3	.86	.36	.60
	Offsite	26	4.8	1.6	2.6	.88	.44	.69
August	Onsite	34	6.2	1.2	3.0	.54	.18	.32
	Offsite	23	6.7	1.2	3.3	.55	.21	.35
September	Onsite	35	5.7	1.3	2.9	.21	.072	.13
	Offsite	22	3.8	1.3	2.6	.23	.047	.14
October	Onsite	33	7.2	1.7	3.9	.14	.054	.098
	Offsite	19	5.2	1.9	3.2	.16	.070	.10
November	Onsite	33	5.5	1.0	2.9	.12	.029	.073
	Offsite	24	6.9	1.3	3.4	.12	.026	.082
December	Onsite	32	4.1	.8	2.5	.10	.030	.062
	Offsite	23	3.9	.4	2.3	.098	.019	.062
Annual summary	Onsite	382	9.0	0.6	3.2 ± 0.1	1.2	0.029	0.30 ± 0.02
	Offsite	288	7.0	0.4	3.1 ± 0.1	0.98	0.019	0.31 ± 0.03

[a] These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products.

Table 2. Gamma-ray radioactivity in air-filter samples, Argonne National Laboratory, January–December 1971

Radionuclide	Location	Concentration ᵃ (fCi/m³)												Annual average
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Antimony-125	Onsite	<1	1	3	4	8	6	6	4	2	1	1	1	3
	Offsite	<1	1	3	5	7	7	7	4	2	1	1	1	3
Barium-lanthanum-140	Onsite	<1	<1	3	<1	<1	<1	<1	<1	<1	1	1	1	<1
	Offsite	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	1	<1
Beryllium-7	Onsite	71	78	88	120	150	120	120	110	110	85	86	65	97
	Offsite	68	76	94	120	120	110	130	120	100	86	92	70	100
Cerium-141	Onsite	<1	2	4	9	10	6	4	2	1	<1	<1	1	4
	Offsite	<1	2	4	9	9	5	5	2	1	<1	<1	1	5
Cerium-144	Onsite	14	18	32	79	130	140	130	78	28	17	10	8	58
	Offsite	14	17	33	77	120	130	140	73	26	17	13	8	56
Cesium-137	Onsite	2	2	3	6	10	10	10	5	2	2	1	1	4
	Offsite	2	2	3	6	9	9	10	5	2	2	1	1	4
Cobalt-60	Onsite	<1	<1	5	10	1	<1	1	<1	<1	<1	<1	<1	<2
	Offsite	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Iodine-131	Onsite	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	10	<10
	Offsite	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	10	<10
Manganese-54	Onsite	<1	<1	<1	<1	1	1	1	1	<1	<1	<1	<1	<1
	Offsite	<1	<1	<1	<1	1	1	1	1	<1	<1	<1	<1	<1
Ruthenium-103	Onsite	3	5	12	29	33	25	19	6	2	1	<1	1	12
	Offsite	3	5	12	29	32	22	18	7	2	1	<1	1	11
Ruthenium-rhodium-106	Onsite	16	18	25	53	88	95	92	55	32	19	16	13	44
	Offsite	17	20	32	56	81	85	95	55	27	19	16	12	43
Zirconium-niobium-95	Onsite	9	24	68	200	300	290	250	110	28	13	7	4	110
	Offsite	9	26	68	200	290	260	270	110	29	14	9	4	110

ᵃFor averaging purposes individual sample results that were less than the minimum detectable concentration were assumed to be one half of the minimum detectable concentration.

made with a spectrometer that used a shielded 35 cm³ lithium-drifted germanium diode as the detector. The detector was calibrated for each nuclide given in table 2.

The activities were either very similar on and off the site, or, for two nuclides, slightly higher on the site. This indicates that most of the airborne particulate activity originated from widespread sources, such as fallout from nuclear test detonations or naturally-occurring materials, and not from localized sources, such as the laboratory. Small amounts of barium-lanthanum-140 and cobalt-60 (up to a maximum of 0.002 percent and 0.07 percent, respectively, of the AEC standards for uncontrolled areas) were detected in some of the samples collection during March, April, May, and July at one location on the laboratory site (10H in figure 1), and were the result of Argonne operations in that area. These two nuclides were not detected off the site at those times; their detection limits are less than 0.0001 percent of the AEC standards.

The alpha radioactivities were normal and in the range found previously. As in the past, most of the beta and gamma radioactivity was due to fission and neutron activation products from nuclear test detonations, although about one-third of the gamma activity and a smaller fraction of the beta radioactivity was due to beryllium-7, which is produced in the stratosphere by cosmic-ray interactions. The total beta radioactivity and most gamma-ray emitters, including the naturally-occurring beryllium-7, increased steadily from January to May, then generally decreased during the remainder of the year. This variation can be attributed to the usual "spring maximum" in the stratospheric fallout rate. The fact that the concentrations of the longer-lived fission products varied in approximately the same manner as beryllium-7 (except that they decreased at a greater rate during the latter part of the year through radioactive decay, since, unlike beryllium-7, they are not produced continuously) is evidence that the bulk of the fission products was also derived from the stratosphere.

The presence of very low amounts of the short-lived fission products, iodine-131 and barium-140 [this nuclide was detected qualitatively, but the concentration (less than 1 fCi/m³) was too low to quantitate] early in January and the sharp increase in 40-day ruthenium-103 and 65-day zirconium-95 in the spring, imply a nuclear test detonation late in 1970 in which some of the fission products were injected into the atmosphere at high altitudes.

The detection of short-lived fission products, iodine-131 and barium-140, at all sampling locations again during the last quarter of the year indicates the presence of fallout from tests that occurred within a few weeks of their detection. These variations in the concentrations of the fission products can be correlated with announced nuclear tests. The average beta radioactivity for the year, 0.3 pCi/m^3, was about 15 percent higher than in 1970, and this difference is accounted for principally by the increased concentrations of intermediate half-life fission products, notably zirconium-niobium-95 and cerium-144, during the second quarter of 1971.

Precipitation collected on the site contained the same fission products found in the air samples. Composite monthly precipitation samples collected through May were also analyzed for iron-55 by radiochemical separation and liquid scintillation counting. Concentrations, expressed in terms of ground deposition, ranged from <2.3 to 15 pCi/m^2, about 20 times less than 1970. Iron-55 was produced principally in nuclear tests conducted in September and October 1961, and the above concentrations have been corrected for decay to October 15, 1961, for comparison purposes. Since iron-55 decays by electron capture and does not emit any gamma-rays, this nuclide does not contribute to the beta and gamma radioactivities given in tables 1 and 2.

Air was sampled continuously for radioiodine with activated charcoal in the 200 and 300 areas because of the possibility of iodine releases in these areas. Very small amounts of iodine-131 were detected early in January and were probably produced in nuclear tests conducted late in 1970, along with the other short-lived fission products found in the air-filter samples. No iodine activity was detected at any other time during the year at either location.

Air sampling for argon-41, a beta emitter with a 1.8 hour half-life that is produced in an operating reactor by neutron irradiation of the stable argon in air, was conducted near the CP-5 reactor (building 330). Samples were collected once a day from 2 to 5 times during each week of reactor operation. Each sampling consisted of two "grab" samples, one taken 50 yards east of the reactor and one downwind from the reactor at a point favorable for detection of argon-41. No samples were collected during August, December, and the second half of July when the reactor was not operating. The results are given in table 3. Because of the timing and location of the sampling collection, the actual average concentration in the vicinity of the reactor was less than the values in the table. The average and maximum concentrations of 86 and 1,200 nCi/m^3 are, respectively, about 2.2 and 29 times the AEC standard for uncontrolled areas and 0.044 and 0.6 times the standard for controlled areas (2 $\mu Ci/m^3$). In this case, comparison with the AEC standard for controlled areas is more appropriate since the sampling is conducted on the site. At the site security fence, the closest uncontrolled approach to the laboratory, the concentrations were less than the detection limit (20 nCi/m^3).

Table 3. Argon-41 concentrations near CP-5 reactor, January–December 1971

Month	Number of samples	Concentration • (nCi/m^3)		Percent of AEC standard	
		Maximum	Average	Maximum	Average
January	36	300	35	750	88
February	32	218	42	545	105
March	38	400	73	1,000	182
April	34	495	49	1,240	122
May	32	1,110	69	2,780	172
June	16	428	37	1,070	92
July	4	453	152	1,130	380
August	0				
September	12	620	140	1,550	350
October	14	880	155	2,200	388
November	16	1,150	107	2,880	268
December	0				
Annual summary	234	1,150	86±6	2,880	215

• Minimum detectable concentration—20 nCi/m^3.

Table 4. Tritium concentrations in air, Argonne National Laboratory, January–December 1971

Date (1971)	300 Area						East area				Offsite			
	Number of samples	Concentration (pCi/m^3)			Percent of AEC standard *		Number of sam-	Concentration (pCi/m^3)			Number of samples	Concentration (pCi/m^3)		
		Maximum	Minimum	Average	Maximum	Average		Maximum	Minimum	Average		Maximum	Minimum	Average
January	26	1,130	1.4	213	0.56	0.11	2	2.3	0.55	1.4	2	0.37	0.23	0.30
February	24	1,160	1.8	267	.58	.13	2	5.8	4.3	5.1	3	4.1	1.0	2.2
March	26	1,570	5.7	355	.78	.18	4	5.3	1.3	3.0	4	2.4	1.0	1.6
April	26	1,630	5.9	331	.82	.17	1	2.2			1	2.0		
May	26	2,150	5.2	234	1.07	.12	2	22	4.2	13	2	7.2	3.6	5.4
June	12	4,080	20.8	847	2.04	.42	1	7.2			1	9.2		
July	10	1,190	60.2	646	.60	.32	1	14			1	12		
August	8	396	20.6	121	.20	.06	1	11			1	7.2		
September	10	1,500	92	370	.75	.18	1	6.1			1	5.4		
October	8	531	116	346	.26	.17	1	1.8			1	2.9		
November	7	1,500	176	594	.75	.30	1	8.6			1	15		
December	10	474	65.1	250	.24	.12	1	13			1	1.4		
Annual summary	193	4,080	1.4	381±21	2.04	0.19	18	22	0.55	7.2±2.2	19	15	0.23	5.4±2.1

*AEC standard for uncontrolled areas.

Tritiated water vapor was monitored in air on and off the site because substantial amounts are in use at the laboratory. Tritium is produced continuously in an operating reactor by several methods. In CP–5 the largest source is by neutron irradiation of the heavy water used for cooling and neutron moderating. Air was sampled for tritiated water vapor at a permanent station 50 yards east of the CP–5 reactor and simultaneously 200 yards downwind of the reactor. The water vapor was removed from the air by absorption on silica gel, and the tritium was measured by counting the water in a liquid scintillation counter. Collection was continuous for the first 6 months of the year and from Monday to Friday during the second half. The results, given in table 4 were all positive, although the concentrations were well below the AEC standards. As in the case of argon-41 near the reactor, application of the standards for controlled areas is appropriate. Since this standard, 5 μCi/m^3 is 25 times larger than that for uncontrolled areas, the percent of standard given in table 4 is reduced by this factor for this comparison.

As will be seen, normal or background tritium concentrations in air during 1971 ranged from about 0.2 to 15 pCi/m^3 and averaged about 5 pCi/m^3. Near CP–5 the average was 380 pCi/m^3, and the difference was due to tritium that left the reactor building. The average concentration near the reactor was about 35 percent higher than in 1970, principally as the result of a small leak in the CP–5 heat exchanger which allowed some of the heavy water to enter the secondary cooling water system and thus escape to the atmosphere. This leak has since been corrected.

Since tritium is produced in nuclear tests and continuously in the upper atmosphere by cosmic-ray interactions with air, tritiated water vapor is present in small concentrations at all locations. To determine the distance from CP–5 that tritium, originating in the reactor, could be detected and distinguished from background tritium, measurements were also made at various distances from the site. Table 5 shows the results of simultaneous collections at CP–5 and in four directions from the reactor. The tritiated water concentration in air is variable, and depends in part on the humidity. During the period of these sample collections, concentrations up to 10–15 pCi/m^3 were normal. The results in table 5 show good correlation with wind direction and indicate that dilution to background levels occurs within 650 yards of the reactors in directions other than that from which the wind is blowing. The site security fence is reached at this distance from the reactor in the southwest corner of the laboratory. At this location, the average and maximum concentrations of the four samples in table 5 were equivalent to 0.02 and 0.09 percent of the AEC standards, respectively.

Table 5. Tritium concentrations in onsite air samples Argonne National Laboratory, 1971

Location	Concentration (pCi/m³)			
	May 7	May 14	May 21	July 13
CP-5	398	240	89	325
650 yards north	14	20	178	23
650 yards west	44	87	6.9	13
650 yards south	22	14	4.5	146
650 yards east	7.8	14	5.6	56
Wind direction [a]	45°–120° (NE-SE)	60°–135° (NE-SE)	190° (S)	270°–300° (W-NW)

[a] Direction from which wind was blowing.

Samples were also collected from 1 to 4 times per month at an onsite location in the East Area 2,000 yards northeast of the reactor and offsite at a location approximately 6 miles northwest of the laboratory. A comparison of the results (table 4) indicate no significant differences between the average concentrations at these two locations. The offsite concentrations may be considered normal for this area; the average and maximum concentrations (5.4 and 15 pCi/m³, respectively) are very similar to those found in 1970 (5.6 and 13 pCi/m³). While the East Area samples did not usually show the effect of CP–5, occasionally, when the wind was from the southwest and the tritium concentration near the reactor was sufficiently high, the concentration reached twice the normal background level. For example, on May 4, when the concentration near CP–5 was 270 pCi/m³, the East Area sample contained 22 pCi/m³ and the wind was from the southwest (i.e., from the direction of CP–5), while the offsite sample concentration was 7.2 pCi/m³. This difference can be attributed to CP–5, and during 1970 this correlation between prevailing wind direction and the concentrations at CP–5 and the East Area occurred a number of times. On this basis, concentrations in the range of 15 to 30 pCi/m³ (0.008 to 0.015 percent of the standards) can be attributed to CP–5 at a distance of 2,000 yards from the reactor in the direction of the wind. This distance is past the site security fence to the west and south of the laboratory, but is within the boundary of the ANL site.

Radioactivity in surface water

Argonne wastewater is discharged into Sawmill Creek, a small stream that runs through the laboratory grounds, drains surface water from much of the site, and flows into the Des Plaines River about 500 yards downstream from the wastewater outfall. Sawmill Creek was sampled upstream from the Argonne site and downstream from the wastewater outfall to determine if radioactivity was added to the stream in Argonne wastewater or from surface drainage. The sampling locations are shown in figure 2. Below the wastewater outfall, the creek was sampled continuously, and the individual samples collected five times weekly. Since it was impractical to analyze all the samples for all the nuclides and elements desired, equal portions of the samples collected each week were combined and analyzed. The results obtained in this way represent the average concentrations in the weekly samples. Above the site, samples were collected bimonthly, and selected samples were analyzed for the same radionuclides as the below outfall samples.

The total (nonvolatile) alpha and beta activities were determined by counting the residue remaining after evaporation of the water, and applying counting efficiency corrections determined for uranium-233 (for alpha activity) and thallium-204 (for beta activity), respectively, to obtain disintegration rates. Tritium was determined by liquid scintillation counting of a separate sample, and this activity does not appear in the total beta activity. Uranium was determined fluorophotometrically, and the results calculated in terms of activity assuming the isotopic composition of natural uranium. Analyses for other radionuclides were performed by specific radiochemical separations followed by appropriate counting. One liter aliquots were used for all analyses except tritium and plutonium (during the second half of the year). Tritium was analyzed by counting 10 ml in a gel system. Beginning in July, plutonium analyses were performed on 10-liter samples by chemical separation followed by alpha spectrometry. Plutonium-236 was used to determine the yield.

Annual summaries of the results obtained for Sawmill Creek are given in table 6. Comparison

Table 6. Radioactivity in Sawmill Creek water, Argonne National Laboratory, January–December 1971

Type of activity	Location	Number of samples	Concentration (pCi/liter)			Percent of AEC standard		
			Maximum	Minimum	Average	Maximum	Minimum	Average
Alpha (nonvolatile)	Upstream	24	4.2	0.6	2.0±0.3			
	Downstream	254	2.7	.5	1.3±.2			
Beta (nonvolatile)	Upstream	24	39	9	24±3			
	Downstream	254	29	11	19±2			
Plutonium * (alpha)	Upstream	6	<.05	<.05	<.05	<0.001	<0.001	<0.001
		3	<.05	<.05	<.05	<.00004	<.00004	<.00004
	Downstream	60	.16	<.05	<.05	.093	<.001	<.001
		60	.0086	<.002	.0038±.0008	.0002	<.00004	.00008
Tritium	Upstream	12	500	<200	360±65	.017	<.0067	.012
	Downstream	253	220,000	300	11,300±3,300	7.3	.010	.38
Uranium (alpha)	Upstream	6	2.0	.66	1.4±.4	.005	.002	.004
	Downstream	60	2.2	.96	1.6±.2	.005	.002	.004
Thorium (alpha)	Upstream	6	<.05	<.05	<.05	<.003	.003	.003
	Downstream	60	<.05	<.05	<.05	<.003	.003	.003
Barium-140	Upstream	5	<2	<.02	<.02	<.007	.007	.007
	Downstream	50	<2	<.02	<.02	<.007	.007	.007
Cesium-137	Upstream	3	<.5			<.003	<.003	<.003
	Downstream	45	2.0	<.5	<.5	.010	<.003	<.03
Iodine-131	Upstream	–	–	–	–			
	Downstream	109	<3	–	–	<1	<1	<1
Strontium-89	Upstream	5	<2	<2	<2	<.07	<.07	<.07
	Downstream	50	<2	<2	<2	<.07	<.07	<.07
Strontium-90	Upstream	5	2.3	.66	1.4±.7	.8	.02	.5
	Downstream	50	2.5	.60	1.6±.4	.8	.02	.5
Technetium-99	Upstream	3	<.5	<.5	<.5	<.0002	<.0002	<.0002
	Downstream	45	.84	<.5	<.5	.0003	<.0002	<.0002

*Two sets of data are given for plutonium because of the introduction in July of a new analytical procedure which improved the sensitivity by a factor of 25. The first set of values for each location covers the first half of the year.

of the results, and 95-percent confidence limits of the averages, for the two sampling locations show that the only nuclides whose presence in the creek water can be attributed to Argonne operations were tritium, plutonium-239, technetium-99, and cesium-137. Approximately 90 percent of the individual samples contained tritium attributable to Argonne, while the other nuclides were found in less than 10 percent of the samples. The concentrations of all four nuclides were quite low compared to the AEC standards. The principal radionuclide added to the creek by Argonne wastewater, in terms of both concentration and percent of the AEC standards, was tritium. The average Argonne contribution of this nuclide to the creek amounted to only 0.4 percent of the standards and the highest concentration in any single sample was equivalent to 7.3 percent of the standards. The principal source of the tritium in Argonne wastewater was the heavy water from the CP-5 reactor that entered the water treatment system because of the heat-exchanger leak discussed in the section on air activity. This was an unusual situation that has since been corrected. The tritium in the creek above the site was produced principally in nuclear tests.

The total alpha and beta radioactivities were higher, on the average, above the site, indicating that at times Argonne wastewater contained less nonvolatile activity than creek water. The high activities above the site are probably due to the water added to the creek by a large (one million gallons per day) municipal sewage treatment plant. The large amount of dissolved solids added in the sewage water is accompanied by a small amount of radioactive nuclides, and tends to increase the concentration in natural creek water. The alpha radioactivities were about one-third lower than in 1970 because the 1971 samples were acidified and filtered prior to analysis to remove suspended solids. These solids, particularly soil, contain considerably more natural activity than the water with which they are associated. This difference is not noticeable in the total beta radioactivity because the water contains appreciable soluble beta activity from natural potassium-40 and from fallout.

In addition to the natural beta radioactivity and that added by wastewater below the outfall, beta radioactivity from nuclear detonations was detected at both sampling locations. The normal nonvolatile beta activity is approximately 5 to 8 pCi/liter above the site and 3 to

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8 pCi/liter below the site, depending on the amount of dilution by wastewater. It is estimated that fallout activity added about 10 to 15 pCi/liter to the nonvolatile beta radioactivity at both locations (fallout is added to the water below the outfall directly from the air as well as by above-site water) and the Argonne contribution below the outfall averaged 1 pCi/liter. The Argonne contribution remained the same as 1970 levels, while the fallout contribution increased by 30 percent.

The same nuclides added to the creek in Argonne wastewater are also produced in nuclear detonations and are constituents of fallout (although some are not present in amounts above the detection limits). The total concentration, regardless of source, must be used in assessing the health hazard of a radionuclide not naturally present, and the percent of the AEC standards for all nuclides listed in table 6 were very low.

Since Sawmill Creek empties into the Des Plaines River, which in turns flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was usually sampled twice a month below and bimonthly above the mouth of Sawmill Creek to determine if the radioactivity in the creek had any effect on the activity in the river. Annual summaries of the radioactivity concentrations at these two locations are given in table 7. Additional samples were collected from the river below Sawmill Creek and analyzed for tritium during August, when secondary CP–5 cooling water into which some of the primary cooling water had leaked, was processed. Except for tritium, the concentrations were in their normal ranges. The natural nonvolatile beta radioactivity in the river is about 5 pCi/liter, and the excess, about 8 pCi/liter was due to fallout. The alpha radioactivity averaged about one-third less than in 1970 for the same reason given in the discussion on Sawmill Creek water; namely, the samples were filtered to remove suspended solids.

The effect of Sawmill Creek water on the tritium concentration at location B is apparent from the table. The average concentration was about twice its normal value, but the percent of AEC standard (0.03 percent) was small. For comparison purposes, the tritium concentration at location B in 1970 averaged about one-third less, 620 pCi/liter. Tritium was the only nuclide found in the Des Plaines River that could be attributed to Argonne wastewater or to Sawmill Creek. Any other activity in Sawmill Creek was diluted to undetectable levels in the river. A comparison of the tritium concentrations in Sawmill Creek and the Des Plaines River taken at appropriate times dur-

Table 7. Radioactivity in Des Plaines River water, Argonne National Laboratory, January–December 1971

Type of activity	Location	Number of samples	Concentration (pCi/liter)			Percent of AEC standard		
			Maximum	Minimum	Average	Maximum	Minimum	Average
Alpha	Upstream	5	3.1	1.1	1.9 ±0.7	....	....	....
(nonvolatile)	Downstream	21	2.0	.6	1.6 ± .2	....	....	....
Beta	Upstream	5	18	6.6	12 ± 4	....	....	....
(nonvolatile)	Downstream	21	21	6.5	14 ± 2	....	....	....
Plutonium	Upstream	3	< .05	< .05	< .05	<0.001	<0.001	<0.001
(alpha)	Downstream	5	< .05	< .05	< .05	< .001	< .001	< .001
Tritium	Upstream	3	580	390	500 ±150	.019	0.013	0.017
	Downstream	41	12,000	<200	980 ±190	.43	< .0067	.033
Uranium	Upstream	2	1.8	1.8	1.8 ± .1	.005	.005	.005
(alpha)	Downstream	5	2.5	1.6	1.9 ± .4	.006	.004	.005
Thorium	Upstream	3	< .05	< .05	< .05	< .003	< .003	< .003
(alpha)	Downstream	5	< .05	< .05	< .05	< .003	< .003	< .003
Barium-140	Upstream	3	<2	<2	<2	< .007	< .007	< .007
	Downstream	5	<2	<2	<2	< .007	< .007	< .007
Cesium-137	Upstream	NS	NS	NS	NS	....	....	....
	Downstream	2	< .5	< .5	< .5	< .003	< .003	< .003
Strontium-89	Upstream	3	<2	<2	<2	< .07	< .07	< .07
	Downstream	5	<2	<2	<2	< .07	< .07	< .07
Strontium-90	Upstream	3	2.5	1.6	2.0 ± .8	.8	.5	.7
	Downstream	5	2.2	1.3	1.7 ± .4	.7	.4	.6

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ing August showed that when the concentration in Sawmill Creek water was about 70 nCi/liter, the average and maximum concentrations in the Des Plaines River, after subtracting the normal concentration, were about 2 and 12 nCi/liter, respectively. This indicates an unexpectedly low dilution factor, about 25, and may be due to incomplete mixing, a below-average water level in the river during August, and the recent substantial increase in the volume of Sawmill Creek water due to the municipal sewage treatment plant. Previous studies gave a dilution factor of about 10^3. The activities in samples of Illinois River water (table 8) were similar to those found in other bodies of water in the area and to the activities found previously at these same locations, and no radioactivity originating at Argonne could be detected.

Table 8. Average radioactivity in Illinois River water Argonne National Laboratory, 1971

Location	Concentration (pCi/liter)			
	Alpha radioactivity	Uranium	Beta radioactivity	Tritium
McKinley Woods State Park [a]	0.89	0.52	7.4	270
Morris [a]	.89	.86	7.7	330
Starved Rock State Park [a]	1.1	.74	8.1	260

[a] Collected October 7, 1971.

Plutonium in soil and grass

Plutonium deposition in soil and grass was measured on and off the site to study the plutonium fallout level in the area from nuclear testing and to determine if any plutonium is present in the environment that might be due to Argonne operations.

Samples were ignited at 600° C. to remove organic matter and prepared for plutonium analysis by treatment with hot hydrochloric, hydrofluoric, and nitric acids. This treatment has been found to solubilize plutonium in soil that has been ignited at 1,000° C. The plutonium was separated from nitric acid solution on an anion-exchange column, electrodeposited, and its composition determined by alpha spectrometry. Alpha spectrometry cannot distinguish between plutonium-239 and plutonium-240, although in the following discussion and in the tables, only plutonium-239 is mentioned. It should be understood that the alpha activity due to the less abundant plutonium-240 isotope is also included. The chemical recovery was determined by adding a known amount of plutonium-236 tracer to the sample before analysis. Soil samples were collected from a known area and depth; the grass samples were obtained by collecting all the grass from a known area.

The results are given in tables 9 and 10. The limits given for the individual results are the statistical counting errors at the 95-percent confidence level, while the limits of the averages are the 95-percent confidence levels of the standard deviation of the average. The analyses of the July and August samples were performed on 20 to 50 gram aliquots of the samples. Although this sample size is sufficient to obtain good accuracy for the plutonium-239 content, the plutonium-238 concentrations were so low that the statistical counting errors were of the order of 100 percent, although positive results were obtained in all cases. The problem was aggravated by the presence of a small amount of plutonium-238 in the plutonium-236 tracer. One hundred-gram portions of the November samples were analyzed, and with this sample size the plutonium-238 counting error was reduced to about 30 percent.

In comparing results from different locations, it is essential to know the sampling depth. Two sampling depths were used for the collections, 0 to 5 cm and 0 to 30 cm. Two samples were subdivided to measure concentration as a function of depth. These results, as well as the averages in table 9 for the two sampling depths, show that one-half to two-thirds of the plutonium down to 30 cm is in the first 5 to 10 cm.

Comparison of the onsite and offsite samples collected from 0 to 5 cm show that the same range and average concentrations exist in all areas for both plutonium isotopes, and it may be concluded that the plutonium in all of these samples resulted from fallout of debris from nuclear detonations. Among the onsite samples

Table 9. Plutonium concentrations in onsite soil, Argonne National Laboratory, 1971

Date collected (1971)	Location [a]	Depth (cm)	Plutonium-239		Plutonium-238		^{238}Pu/^{239}Pu [b]
			(fCi/g)	(nCi/m²)	(fCi/g)	(nCi/m²)	
6-17	10P	0-5	21 ±2	1.0 ±0.1	0.9 ±0.9	0.04 ±0.04	0.04
6-17	8N	0-5	16 ±2	.75 ± .11	.8 ± .8	.04 ± .04	.05
6-17	12C	0-5	25 ±2	1.3 ± .1	1.2 ±1.1	.06 ± .06	.05
6-18	14L	0-5	24 ±2	1.2 ± .1	1.1 ±1.1	.05 ± .05	.04
6-18	14N	0-5	30 ±2	1.4 ± .1	.9 ± .9	.04 ± .04	.03
6-18	14E	0-5	19 ±2	.85 ± .06	1.0 ±1.0	.05 ± .05	.06
6-18	7E	0-5	26 ±2	1.1 ± .1	1.0 ±1.0	.04 ± .04	.04
6-18	4G	0-5	10 ±2	.42 ± .06	.6 ± .6	.02 ± .02	.05
8-24	13N	0-5	29 ±2	1.8 ± .1	2.0 ±2.0	.1 ± .1	.06
8-24	14I	0-5	19 ±2	.93 ± .07	1.0 ±1.0	.05 ± .05	.05
8-24	17H	0-5	16 ±2	1.1 ± .2	1.7 ±1.7	.13 ± .10	.12
8-24	10E	0-5	18 ±2	1.0 ± .2	1.3 ±1.3	.08 ± .08	.08
8-24	13D	0-5	24 ±2	1.9 ± .1	1.0 ±1.0	.08 ± .08	.04
8-24	6J	0-5	16 ±2	1.0 ± .2	.6 ± .6	.03 ± .03	.03
8-24	8L	0-5	24 ±2	1.5 ± .1	2.1 ±1.6	.1 ± .1	.07
8-24	5H	0-5	17 ±2	1.1 ± .2	.7 ± .7	.04 ± .04	.04
8-24	5D	0-5	18 ±2	1.1 ± .1	1.2 ±1.2	.07 ± .07	.06
8-24	10M	0-5	14 ±2	.93 ± .14	.9 ± .9	.06 ± .06	.06
8-24	9N	0-5	24 ±2	1.5 ± .1	1.2 ±1.2	.07 ± .07	.05
8-24	10N	0-5	9.4 ±1.0	.70 ± .11	.8 ± .8	.06 ± .06	.09
8-24	15O	0-5	27 ±2	1.3 ± .1	.9 ± .9	.04 ± .04	.03
8-24	16J	0-5	20 ±2	1.0 ± .1	1.1 ±1.0	.06 ± .05	.06
8-25	11C	0-5	22 ±2	1.2 ± .1	1.0 ± .7	.05 ± .04	.04
8-25	15F	0-5	21 ±2	.92 ± .09	.8 ± .8	.40 ± .04	.04
8-25	15F	5-10	14 ±2	.61 ± .09	.6 ± .6	.03 ± .03	.05
8-25	15F	10-15	1.4 ±.8	.11 ± .04	.2 ± .2	.01 ± .01	.09
Average				1.2 ±0.14		0.06 ±0.01	
11-11	12M	0-20	24 ±1	4.1 ± .2	.8 ± .2	.14 ± .05	.03
11-11	12M	0-30	12 ± 1	1.9 ± .2	.9 ± .3	.13 ± .04	.07
11-11	12M	0-30	21 ±1	2.9 ± .2	.8 ± .3	.10 ± .04	.03
11-11	12M	0-30	13 ± .1	2.1 ± .2	.8 ± .3	.12 ± .04	.06
11-11	11G	0-30	9.2 ±1	1.1 ± .1	.6 ± .2	.07 ± .02	.06
11-11	11G	0-30	18 ±1	2.1 ± .1	1.0 ± .3	.11 ± .03	.05
11-11	10H	0-30	15 ±1	2.0 ± .1	.9 ± .3	.12 ± .04	.06
11-11	10H	0-20	13 ±1	2.4 ± .2	.7 ± .2	.12 ± .03	.05
11-11	8I	0-30	14 ±1	2.2 ± .2	.6 ± .2	.09 ± .03	.04
11-11	8I	0-30	14 ±1	2.2 ± .2	.9 ± .3	.14 ± .05	.06
11-11	9I	0-7.5	18 ±1	1.7 ± .1	.8 ± .2	.08 ± .02	.04
11-11	9I	7.5-15	4.5 ± .4	.42 ± .04	.7 ± .2	.06 ± .02	.14
11-11	9I	15 -22.5	2.5 ± .3	.28 ± .03	.1 ± .5	.02 ± .1	.04
11-11[c]	9I	22.5-30	2.7 ± .3	.25 ± .03	.7 ± .2	.06 ± .02	.24
11-11	9H	0 -30	13 ± 1	1.9 ± .1	.7 ± .2	.11 ± .03	.06
Average				2.3 ± .4		.12 ± .02	

[a] The locations are given in terms of the grid coordinates in figure 1.
[b] As calculated from concentrations in nCi/m².
[c] For average purposes, these results form a single sample.

Table 10. Plutonium concentrations in offsite soil, Argonne National Laboratory, 1971

Date collected (1971)	Location [a]	Plutonium-239		Plutonium-238		^{238}Pu/^{239}Pu
		(fCi/g)	(nCi/m²)	(fCi/g)	(nCi/m²)	
9-28	German Church & Wolf Roads, Willow Springs	7.4 ±0.2	0.25 ±0.05	0.75 ±0.64	0.025 ±0.021	0.10
9-28	McCormick Woods, Brookfield	30 ±2	1.5 ± .1	1.8 ± .9	.093 ± .047	.06
10-5	Magician Lake Park, Mich	74 ±4	.66 ± .03	4.2 ±1.9	.038 ± .017	.06
10-7	Starved Rock State Park	16 ±2	1.0 ± .2	.9 ± .9	.06 ± .06	.06
10-7	McKinley Woods State Park	22 ±2	1.1 ± .1	1.2 ±1.1	.057 ± .052	.05
10-12	Delavan, Wisc	40 ±2	2.3 ± .1	1.9 ±1.3	.11 ± .08	.05
10-12	Pioneer Park, Naperville	24 ±2	2.1 ± .2	1.9 ±1.3	.17 ± .10	.08
10-14	Park Forest	38 ±2	1.6 ± .1	1.8 ±1.2	.076 ± .050	.05
10-14	Monticello, Ind	8.9 ± .2	.48 ± .10	1.0 ±1.0	.05 ± .05	.11
Average			1.2 ±0.5		.08 ±0.03	

[a] Sampling depth is 0-5 cm.

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Table 11. Plutonium content of soil, 1969–1971

Reporting laboratory	Sample location	Date	Depth (cm)	Concentration (nCi/m²)		Reference
				Plutonium-239	Plutonium-238	
New York AEC Health & Safety Laboratory:	Argonne Park: (12-0, figure 1)	1970	0–30	2.1	0.07	(*4*)
	New York City (5 samples)	1970	0–20 0–30 0–60	2.0—2.6	----------	(*2,3*)
	West, Midwest U.S. (4 samples)	1970	0–20	1.8—2.4	----------	(*3*)
	New York City	1969	0–5	1.6	.07	(*3*)
	New York City	1969	5–20	.4	.03	(*3*)
Lawrence Radiation Laboratory:	Livermore, Calif. (7 samples)	1971	0–20	.6—2.6	.02— .29	(*5*)

collected to a depth of 30 cm, one sample, containing 4.1 nCi/m² of plutonium-239, is outside the range expected from fallout. The plutonium concentrations in the remainder of the 0-30 cm group are normal for this area. This group of samples was collected near buildings in which plutonium has been used, so the possibility of plutonium in their vicinity exists. The area in which the above-normal sample was collected is being analyzed in detail to determine if plutonium contamination does, in fact, exist since the single value obtained thus far is not sufficiently high to allow an unequivocal conclusion.

Except for the one sample mentioned above, the deposition concentrations found on and near the site are similar to those reported by other laboratories, and attributed by them to fallout. These are summarized in table 11. The plutonium-239 content of grass (table 12) was similar on and off the site, and in terms of deposition, about one to two thousand times less than in soil from the same location.

Table 12. Plutonium-239 concentrations in grass Argonne National Laboratory, 1971

Date collected (1971)	Location	Concentration	
		(fCi/g dry weight)	(pCi/m²)
Onsite:			
6/17	8N	3.7 ±1.7	0.53 ±0.24
6/17	12C	1.9 ± .9	.12 ± .06
8/24	13N	5.2 ±1.4	1.1 ± .3
8/24	8L	4.3 ±1.8	.78 ± .33
8/24	10M	2.3 ±1.1	.50 ± .24
Offsite:			
9/28	German Church & Wolf Roads, Willow Springs	2.2 ±1.1	.77 ± .39
10/7	McKinley Woods State Park	5.5 ±3.4	2.1 ±1.3

Radioactivity in milk

Raw milk was collected monthly from a local dairy farm and analyzed for several fission products. Barium-140, strontium-89, and iodine-131 were not present in concentrations greater than the minimum detectable amounts of 20 pCi/liter for iodine-131 and 2 pCi/liter for the other two nuclides. The cesium-137 and strontium-90 concentrations are given in table 13. These two nuclides are long-lived fission products from past nuclear tests and their presence in milk is not related to Argonne operations. The average strontium-90 content decreased by 20 percent from last year, while the cesium-137 concentrations were nearly unchanged.

The concentrations given in table 13 may be compared to the AEC standards for drinking water. These values are 300 pCi/liter for strontium-90 and 20 nCi/liter for cesium-137 if the daily intake of water is 2.2 liters. The consumption of 1 liter of milk per day would then result in an average intake of 0.85 percent of the strontium-90 and 0.03 percent of the cesium-137 AEC standards. Using the standards specified by the Federal Radiation Council, 1 liter of milk is equivalent to 0.85 and 2.8 percent of the daily intake guides for cesium-137 and strontium-90, respectively.

Table 13. Cesium-137 and strontium-90 concentrations in milk, Argonne National Laboratory, 1971

Date collected (1971)	Concentration (pCi/liter)	
	Cesium-137	Strontium-90
January 6	<10 [a]	6.5
February 3	<10	7.1
March 3	17	5.8
April 7	16	5.8
May 5	40	4.9
June 2	26	4.8
July 7	12	7.0
August 4	12	6.8
September 1	13	6.1
October 6	16	4.1
November 3	<10	4.6
December 1	12	3.2
Average	15	5.6

[a] <10 = 5 for averaging purposes.

Table 14. Environmental penetrating radiation, Argonne National Laboratory, 1971

Location [a]	Period of measurement	Days	Dose (mrem/a)
Near site security fence:			
12P	10/12—11/8	27	125
8H	10/12—11/8	27	131
10E	10/12—11/8	27	93
9L	10/22—12/14	53	108
14I	10/22—12/14	53	117
10M	11/5 —12/14	39	106
14L	11/5 —12/14	39	114
14EF	11/5 —12/14	39	96
18J	11/5 — 1/3	59	102
13D	11/5 —12/14	39	74
8F	11/5 —12/14	39	126
12N	11/12—12/13	31	101
9–10L	11/12— 1/3	52	118
10M	11/12— 1/3	52	105
9EF	11/12— 1/3	52	102
14G	11/12— 1/3	52	110
Average			108 ±7
Offsite:			
Woodridge	10/12—11/8	27	93
Downers Grove	11/5 —12/14	39	117
Lemont	11/5 —12/14	39	119
Woodridge	11/5 —12/14	39	96
Lombard	11/12— 1/4	53	115
Route 83	11/12— 1/3	52	85
Average			104 ±12

[a] Locations shown in figure 1.

Penetrating radiation

Measurements of gamma-ray dose were made beginning October 12 at several locations at or near the site security fence to determine the dose that might be due to Argonne operations at the nearest uncontrolled approach to the laboratory. The dose was measured with thermoluminescent dosimeters (dysprosium-activated calcium fluoride crystals and dysprosium-activated calcium sulfate powder dispersed in Teflon) calibrated against an NBS standard radium-226 source. The results are given in table 14 together with offsite measurements made at the same time. The onsite locations are shown in figure 3 together with the dose.

The averages and their confidence limits show that there was no statistically significant difference between the average dose off the site and at the site fence. However, to determine if any fraction of the site-fence dose is assignable to Argonne, the results must be examined in more detail. Except for the dosimeter at the Route 83 location, which was located on the second floor porch of an apartment building, and thus was partially shielded from both cosmic and terrestial radiation, the offsite dosimeters, which were mounted on trees or posts away from buildings, received doses between 93 and 119 mrem/year. The site-fence readings ranged from 74 to 131 mrem/year. The lowest onsite doses were obtained at the western edge of the site (800 Area), where the ground contains considerable gravel. Since the gravel contains less radium and thorium than clay soil, the terrestial portion of the dose in this area should be lower, and this probably accounts for the lower average readings. Except for the dose of 125 mrem/year in Argonne Park, the highest readings were obtained from the dosimeters located on the south fence line (126 mrem/year at 8F and 131 mrem/year at 8H). The Argonne Park reading appears anomalous since lower and more normal readings were obtained closer to ANL facilities. Neglecting the Argonne Park value pending additional measurements in that area, a reasonable range for the normal dose on the ANL fence and in the ANL environs is between 95 and 120 mrem/year, if one considers the offsite values as normal. Thus, the dose at the south fence that might be attributed to Argonne operations is perhaps 5 to 30 mrem/year. This conclusion must be considered tentative since values of 125 to 130 mrem/year may be natural in some locations. Certainly the dose at the fence line is not greater than the estimate. A better assessment of the dose due to ANL can be made when measurements are available for a longer period of time, perhaps 1 year, and at additional locations.

The annual whole body dose in uncontrolled areas permitted by AEC Manual Chapter 0524 is 500 mrem above natural background, and the dose at any fence line due to laboratory operations is well within this limit. The 500 mrem dose limit may be reduced in the future, probably to some value between 5 and 25 mrem/year, which is of the same order as the maximum dose estimate given above. When and if the change occurs, a better value for the dose due to ANL operations should be available.

Recent coverage in *Radiation Data and Reports:*

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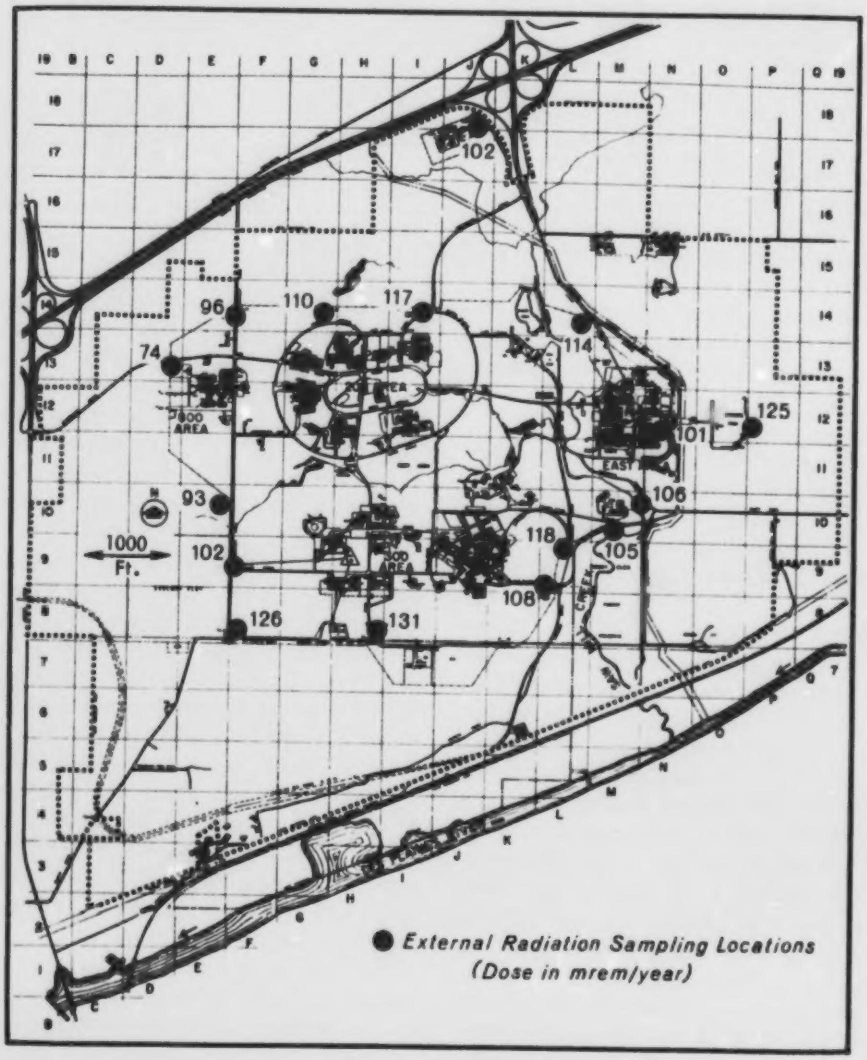
102
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800 AREA
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1000 Ft.
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105
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300 AREA
108
126
131
CREEK
N
● *External Radiation Sampling Locations (Dose in mrem/year)*

Figure 3. External radiation measurements, Argonne Laboratory

Reported Nuclear Detonations, April 1973

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals, presumably from a Soviet underground nuclear explosion were recorded by the United States on April 19, 1973. The signals originated at approximately 11:30 p.m. EST, at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

Announcement was made by the U.S. Atomic Energy Commission of two underground U.S. nuclear tests during April 1973. One was conducted April 25, 1973 and the other, April 26, 1973. Both tests were conducted underground by the Atomic Energy Commission at its Nevada Test Site and were of the low-intermediate yield range of 20 to 200 kilotons TNT equivalent.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

TRITIUM BURDENS IN TWO ARCTIC VILLAGES. *J. A. Eckert* and *R. B. Evans. Radiation Data and Reports,* Vol. 14, May 1973, pp. 273–275.

During a routine visit to measure cesium-137 burdens in residents of two Alaskan villages, drinking water and urine samples were collected and subsequently analyzed for tritium by the National Environmental Research Center-Las Vegas. The mean concentrations at Noatak, Alaska, were 1,200 pCi/liter and 1,500 pCi/liter for tritium in drinking water and urine, respectively. At Kiana, the mean tritium concentration in drinking water was <400 pCi/liter, and the mean tritium concentration in urine was 1,000 pCi/liter.

KEYWORDS: Alaska, body burden, tritium.

RADIATION DATA AND REPORTS

Volume 14, Number 6, June 1973

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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Reports

Summary of Environmental Monitoring at Philadelphia, 1958–1971

J. E. Lieberman,[1] *R. D. Ice,*[2] *M. Green,*[3] *and R. McGrattan*[4]

The City of Philadelphia maintains an environmental radiation surveillance program for evaluating the environment of the Delaware Valley. The program has evolved from the initial goals of setting operational guides for the collection and analyses of data at sites of nuclear ship operations, through preoperational radiological data collection associated with the construction of the N.S. *Savannah*, through a nuclear weapons fallout evaluation, to the present objective of providing environmental surveillance of nuclear facilities.

A 13-year compilation of environmental data from the City of Philadelphia is presented. Included are gross alpha and gross beta results of raw and finished surface waters, gross beta results of air samples, and strontium-90 and iodine-131 quantities in pasteurized milk.

Environmental radiation surveillance at Philadelphia started in 1958 as a cooperative program for evaluating the Delaware River and bay. The surveillance program involved the United States Public Health Service (USPHS), the City of Philadelphia Health Department, New Jersey Health Department, Pennsylvania Health Department, Delaware Health Department, and the New York Shipbuilding Corporation (NYS).

The City of Philadelphia is actively involved in environmental radiation surveillance. The program complements the Pennsylvania Health Department Program with funds and equipment, integrates the city-wide air pollution and water assays that involve radioactive elements, serves as an early warning indicator of radiological hazards, provides immediate expertise to city disaster coordinators and basic scientific data for health hazards and program evaluation.

The initial objective of the program was twofold. First, to establish operational guides for the collection and analysis of environmental samples in the general area of nuclear ship operating sites. The second objective was to provide preoperational radiological data for the construction and test area of the N.S. *Savannah*. The first objective resulted in a protocol for radiological surveys (*1*) used by USPHS at all U.S. ports visited by the N.S. *Savannah* from 1963 to 1965. The second objective was completed when the N.S. *Savannah* started sea trials in 1962.

New York Shipbuilding Corporation (now doing business as Merritt, Chapman and Scott) builders of the N.S. *Savannah*, initiated radiation environmental sampling of the Delaware River in July 1958 under the direction of Dr. H. Locke. In March 1959, the USPHS established seven river and tributary water sampling stations on the Delaware River and one station on the Schuylkill River. The Robert A. Taft Sanitary Engineering Center and the Technical Operations Branch, Southeastern Radiological Health Laboratory, analyzed the samples (*2–5*). Between 1962 and 1965, the surface water sampling program was expanded under the direction of the Engineering Program at the Northeastern Radiological Health Laboratory (NERHL). In 1965, the cooperative program involving the USPHS was terminated.

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Because of the increased concern for fallout from nuclear weapons tests, and because the initial objectives of the radiation surveillance program associated with the building of the nuclear ship *Savannah* were almost completed, the surveillance program was reoriented to an assessment of radioactive fallout in August 1961. In addition to gross beta and gamma measurements of surface water, gross beta and gross gamma measurements of air, gross beta measurement of precipitation, and gross beta measurement of process water were initiated.

With the abrupt ending of the nuclear weapons aerial test ban by the Soviet Union on September 1, 1961, the Philadelphia air sampling program was expanded from one to three stations during September. In October 1961, the program was expanded to the analyses of a composite milk sample for gross beta and iodine-131 radioactivity. Gross gamma counting of precipitation was initiated in November 1961. In January 1962, gross gamma analysis of surface water samples was added to the existing measurement of gross beta radioactivity.

The first indications of fallout appeared in air samples collected September 15, 1961. Daily beta and gamma radioactivity in air from August 1 through September 14 remained consistently below 1 pCi/m^3. The largest quantity of radioactivity in air was recorded on September 16, 1961 and was 73.8 pCi/m^3 of gross gamma radioactivity. The highest daily average of the three stations, also on September 16, was 63.4 pCi/m^3 of gross beta and 132 pCi/m^3 of gross gamma. Recent changes in radioactivity of air samples have been correlated to current Chinese and French bomb tests.

To bring the analytical procedures into conformity with those of the USPHS, the Philadelphia Health Department revised their analysis procedures for surface water samples in March 1965. Gross gamma analysis of surface water was discontinued and gross beta radioactivity was determined on the suspended and dissolved solid fractions of a water sample in place of the total solids analysis.

Gross gamma analysis of surface water was replaced as the early warning indicator of gamma activity in the environment by a radiochemical program for analyzing iodine-131 in milk. An assessment of strontium-90, strontium-89, barium-140, and lanthanide radioactivity was also initiated in March 1965 as part of the milk analyses.

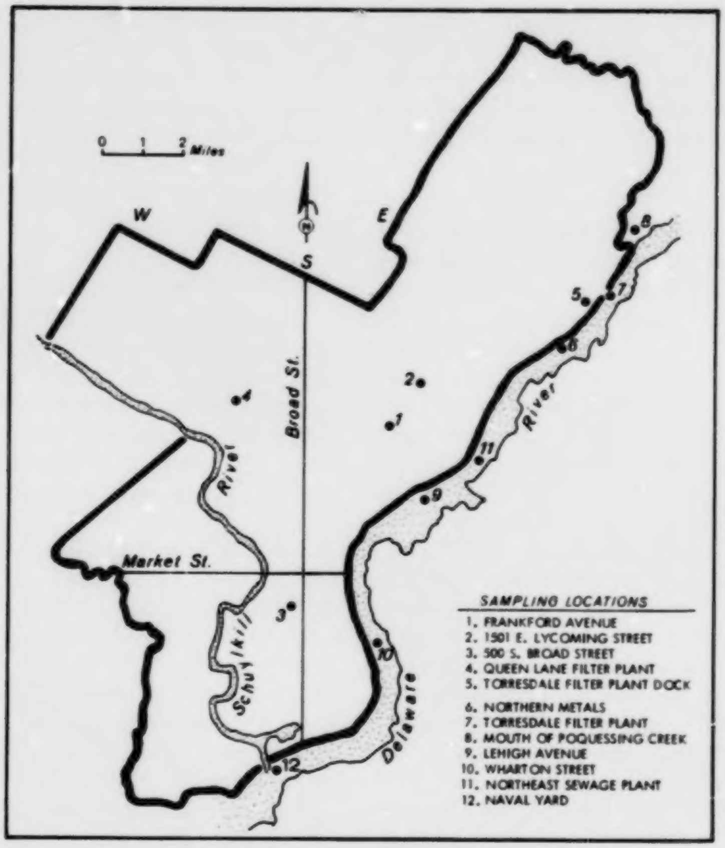
Table 1. Radiation Environmental Surveillance Program, Philadelphia

Sample	Location	Frequency	Activity measured
Air	3200 Frankford Avenue [a]	Daily	Gross beta
	1501 E. Lycoming Street	Daily	Gross beta
	500 S. Broad Street	Daily	Gross beta
River water	Schuylkill River:		
	Queen Lane Filter Plant	Weekly	Suspended alpha and beta Dissolved alpha and beta on all river water samples
	Delaware River:		
	Torresdale Filter Plant Dock (T-1)[b].	Weekly	
	Torresdale composite (T-2)[b] 1/3 Northern Metals 1/3 Torresdale Filter Plant 1/3 Mouth of Poquessing Creek.		
	Lehigh Avenue [b]	Weekly	
	Wharton Street [b]	Weekly	
	Northeast Sewage Plant [b]	Weekly	
Tap water	500 S. Broad Street	Weekly	Gross alpha and gross beta
	1501 E. Lycoming Street	Weekly	Gross alpha and gross beta
Precipitation	1501 E. Lycoming Street	After each rain	Suspended alpha and beta Dissolved alpha and beta
Milk	Composite	Weekly	Strontium-90 [c] Iodine-131

[a] Discontinued October 1970.

[b] Collected from midchannel using city's boat, *Aquadelphia II*.

[c] If iodine levels are >10 pCi/liter, the milk is analyzed for strontium-89 and barium-140 and also is subjected to gamma spectroscopy.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12
SAMPLING LOCATIONS
1. FRANKFORD AVENUE
2. 1501 E. LYCOMING STREET
3. 500 S. BROAD STREET
4. QUEEN LANE FILTER PLANT
5. TORRESDALE FILTER PLANT DOCK
6. NORTHERN METALS
7. TORRESDALE FILTER PLANT
8. MOUTH OF POQUESSING CREEK
9. LEHIGH AVENUE
10. WHARTON STREET
11. NORTHEAST SEWAGE PLANT
12. NAVAL YARD

Figure 1. Sampling locations for Radiation Surveillance Environmental Program, Philadelphia

In 1965, the City of Philadelphia expanded its surface water sampling to include the sampling sites discontinued by the USPHS in the Delaware and Schuylkill Rivers. At present, the City of Philadelphia is monitoring raw surface water at four stations on the Delaware River and one station on the Schuylkill River plus a composite of Delaware River water.

The present City of Philadelphia Environmental Surveillance Program consists of the sampling stations and frequencies indicated in table 1. The location of sampling stations are indicated in figure 1.

The U.S. Geological Survey monitored tritium in the Delaware River at Philadelphia between 1964 and 1968 (*6*). The Delaware River has been assessed for gross radioactivity as part of the Water Pollution Surveillance System of the Public Health Service (*7*). The Philadelphia results (*7*) are presented in this report for comparison purposes.

In 1970, an ad hoc committee on radiation surveillance of the Delaware River Basin was formed to review the existing Delaware River Environmental Surveillance Program. The objectives of the committee were:

1. to review all accrued data and report the findings to the public,
2. to coordinate all surveillance within the Delaware Valley Basin minimizing duplication and to conserve resources, and
3. To reorient the existing program from a surveillance program, indicative of weapons testing, to a nuclear facility oriented surveillance program.

The City of Philadelphia, as the only major city with an expanded environmental radiation surveillance program, is assisting in this regional approach to the evaluation of the environment. This report is a result of this interdisciplinary cooperative program.

Air monitoring

High volume air samplers provide daily filters for analysis of radioactivity in air. The Air Management Services Unit removed the filter from the air sampler. Samples were obtained from three locations (table 1). From an effective air filter area of 7¼- by 9 inches, two 1⅞-inch-diameter discs were removed and placed into 2-inch planchets. The planchets were identified by date and location and stored in a dessicator until counted in a Beckman Wide Beta Counter. All filters were counted for 10 minutes on day three or day five after collection to allow assaying of samples collected each day of the week during a 5-day work week. The counter efficiency was determined using a radium D and E sealed source. The minimum detectable activity (MDA) at the 95-percent confidence level was 0.007 pCi/m^3. The minimum reported activity was 0.01 pCi/m^3.

Prior to July 1966, a Baird Atomic GM Scaler Model 123 with a GM end-window tube (1.4–2.0 mg/cm^2 thickness) was used. Sample efficiency was determined using a calibrated bismuth-210 source, the minimum reported activity with the GM scaler was 0.3 pCi/m^3.

Gross gamma measurements between August 1961 and July 1963 were made with a 3-inch NaI (Tl) scintillation detector. Counter efficiency was determined with a cesium-137 calibration source. The crystal had an average efficiency for cesium-137 of 28 percent. The results of air measurements are presented in table 2 and figure 2.

Water monitoring

The New York Shipbuilding Corporation sampled at three locations within the shipyard. Between July 1958 and December 1958, the sample results represent the average of daily samplings. Beginning in January 1959 through December 1965, results from weekly composite samples averaged for three locations were reported. Samples of 500 ml containing suspended and dissolved materials were evapoated under an infrared lamp onto planchets and counted for 1,000 counts using a GM counter having an end window thickness of 1.4 mg/cm^2.

From 1962 to 1965, the NERHL collected grab samples of river water at three stations in Camden, N.J. on a monthly basis. These samples were filtered to separate suspended solids and the suspended solids were counted for gross alpha and gross beta radioactivity. The results are presented in table 3. Sulfides and carbonates were precipitated from the filtrate and counted for gross alpha and gross

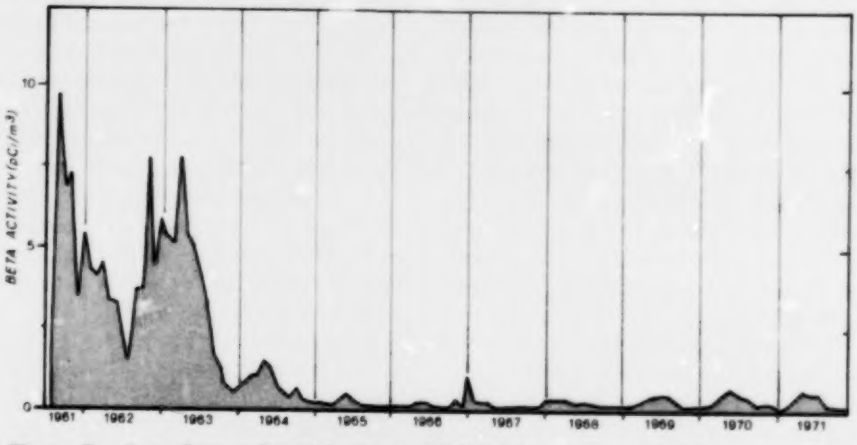

Figure 2. Gross beta radioactivity in air, Philadelphia, August 1961-December 1971

beta radioactivity.[5] The results are reported in table 3.

Between August 1961 and February 1965, the City of Philadelphia monitored gross beta and gross gamma radioactivity in the Delaware River and the Schuylkill River. Through December 1963, the reported results are the mean of 10 grab samples taken throughout the month. Beginning in January 1964, weekly grab samples were obtained, and the monthly results represent an average of four or five weekly analyses.

A 250 ml water sample was acidified with nitric acid, evaporated to 5 ml and counted in a 3-inch NaI(Tl) well counter. The count rate was compared to the efficiency of a cesium-137 standard well source. The 5 ml sample was then evaporated to dryness in a planchet and counted using a GM tube with a minimum detectable activity for beta radiation of 15 pCi/liter.

In March 1965, gross gamma counting of water samples was discontinued, and gross alpha analysis of suspended and dissolved solids was instituted.

In October 1965, additional weekly grab samples of raw river water at Wharton Street, Lehigh Street, and the Navy Yard were added to the environmental survey program. The Delaware River samples are collected by the city's boat, *Aquadelphia II*. All samples are taken from midchannel (average depth 35–40 feet) from a pipe extending 12 inches below the river's surface. Each sample of 500 ml was acidified with 1.5 N HC1 and filtered through a Whatman No. 12 filter paper. The filter paper was dried and ignited in a muffle furnace for 2 hours at 550° C. and then cooled. The residue was transferred to a planchet, weighed and counted.

The filtrate was evaporated to 10 ml, gradually transferred to a planchet, and finally evaporated to dryness using an infrared lamp. The planchets were dried for 2 hours at 110° C. to constant weight and counted.

The samples were counted using a Nuclear Measurement Corporation model PC 3A proportional counter having a minimum detectable activity of 1.5 pCi/liter. The filtrate (dissolved solids) and residue (suspended solids) results are reported in table 3.

In August 1966, the laboratory began counting gross alpha and gross beta radioactivity using a Beckman Wide Beta II proportional counter. The minimum detectable beta activity with the procedures used was 1.0 pCi/liter. The minimum detectable alpha activity with the procedures used was 0.4 pCi/liter.

Precipitation and process water

The procedures used for precipitation and process water are the same as those used since 1966 with raw surface water. The precipitation and process water samples were obtained at 1501 E. Lycoming Avenue (table 4).

Milk analyses

A composite 1-gallon whole milk sample from dairies in the Delaware Valley is received weekly by the environmental radioassay laboratory. Immediately after collection of the milk sample, 1 liter is removed for iodine analysis and 3 ml of 37 percent formaldehyde solution per liter is added to the remainder for milk preservation. The remaining milk sample is stored for 2 weeks to allow ingrowth of yttrium-90 to equilibrium.

Iodine ion is separated from the milk using a Dowex 1-X8 anion exchange resin. The whole milk is passed through the anion exchange resin in a column and the resin transferred to counting tubes designed to fit within the 3-inch NaI (Tl) well crystal. The amount of iodine-131 is determined by counting the photopeak radioactivity using a differential count mode. The amount of radioactivity within the milk sample is compared to a known quantity of iodine-131 iodide ion that has been added to a second liter of milk, separated on the anion exchange resin and counted under the same conditions. The minimum detectable activity for iodine-131 under the counting conditions used was 10 pCi/liter. Based upon a practical reporting level, quantities less than 10 pCi/liter have been considered insignificant (*9*).

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[5] Personal communication, James A. Hardin, Delaware River studies, radiochemical (January 12, 1971). Northeast Radiological Health Laboratory, Winchester, Mass.

Table 2. Gross beta radioactivity in surface air,[a] Philadelphia, August 1961 to December 1971

Sampling by station & year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1961												
Gross gamma average of all stations								0.4	18.2	7.9	11.2	4.2
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford								Started 9/6/61	8.7	6.0	6.4	3.6
City Hall Annex								Started 9/10/61	11.9	6.7	6.8	3.4
3200 Frankford, horizontal								.4	9.3	7.8	8.5	3.6
Air surveillance, all Philadelphia stations gross beta (pCi/m³):												
Maximum								.7	73.8	17.5	27.4	10.9
Minimum								<.1	<.1	1.5	2.0	.2
Average [b]								.4 (31)	9.9 (68)	7.2 (93)	7.3 (88)	3.5 (92)
1962												
Gross gamma average of all stations	6.9	5.2	4.9	5.3	3.8	3.7	3.0	1.8	5.1	5.5	11.1	5.7
Average gross beta radioactivity, per station (pCi/m³):												
3200 Frankford	5.6	4.9	4.2	4.8	3.5	3.3	2.6	1.5	3.9	3.4	9.0	4.3
City Hall Annex	5.6	4.1	4.1	4.3	3.3	3.4	2.6	1.4	3.2	3.5	7.1	4.3
3200 Frankford (horizontal)	5.7	4.3	4.1	4.6	3.4	3.3	2.6	1.4	4.0	4.3	7.4	4.7
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	10.1	11.2	8.9	8.6	6.5	6.9	5.2	3.1	12.7	12.0	33.5	11.7
Minimum	2.3	.3	.3	.6	.3	.1	.8	.2	.3	.2	.9	1.0
Average [b]	5.6 (89)	4.4 (83)	4.1 (90)	4.6 (90)	3.4 (91)	3.3 (88)	2.6 (91)	1.4 (91)	3.7 (87)	3.8 (93)	7.8 (83)	4.4 (76)
1963												
Gross gamma average of all stations	7.5	6.3	5.9	9.5	6.4	5.6	4.6					
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	6.2	5.1	4.7	7.5	5.6	5.0	4.2	3.2	1.7	1.4	.7	.6
City Hall Annex	5.5	5.8	5.2	7.2	5.1	5.0	4.2	3.2	1.9	1.3	(c)	—
3200 Frankford (horizontal)	6.2	5.5	5.5	8.6	5.8	5.1	4.1	3.2	1.8	1.3	.7	.5
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	12.7	9.5	12.2	22.9	14.0	10.4	8.5	6.6	3.7	2.2	2.1	1.1
Minimum	.4	2.2	1.6	1.2	1.4	.6	1.4	.6	.2	.4	<.1	<.1
Average [b]	5.9 (89)	5.5 (75)	5.1 (89)	7.8 (89)	5.5 (91)	5.0 (90)	4.2 (93)	3.2 (91)	1.8 (83)	1.4 (75)	.7 (60)	.5 (63)
1964												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	.7	.9	1.1	1.0	1.4	1.4	.6	.5	.3	.7	<.3	<.2
City Hall Annex	1.3	.8	1.0	2.4	2.8	2.3	—	.8	Began 1501			
1501 E. Lycoming										1.0	<.3	<.2
3200 Frankford (horizontal)	.6	.7	.9	1.0	1.5	1.3	.5	.4	.3	.6	.3	.2

Air surveillance, all Philadelphia stations, gross beta pCi/m³):												
Maximum	1.4	1.8	1.8	2.4	3.2	3.3	1.6	1.0	.8	5.6	.7	.6
Minimum	.1	.2	.2	.1	.2	.3	<.1	<.1	<.1	<.1	<.1	<.1
Average^b	.7 (62)	.8 (60)	1.0 (63)	1.1 (60)	1.5 (63)	1.4 (61)	.6 (60)	.5 (62)	.3 (60)	.7 (75)	<.3 (82)	2.2 (91)
1965												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	<.2	<.2	<.2	<.2	<.4	.5	<.3	<.2	<.1	<.1	<.1	<.1
1501 E. Lycoming	<.2	<.2	<.2	<.2	<.3	.4	.2	<.2	<.1	<.1	<.2	<.1
500 S. Broad	<.2	<.2	<.2	<.2	<.3	.5	.3	<.2	<.1	<.1	<.2	<.1
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	<.2	<.2	<.2	<.2	<.3	.5	<.3	<.2	<.1	<.1	<.2	<.1
Minimum	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
Average^b	<.2 (89)	<.2 (78)	<.2 (89)	<.2 (86)	<.3 (88)	.5 (90)	<.3 (90)	<.1 (93)	<.1 (90)	<.1 (92)	<.2 (85)	<.1 (93)
1966												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	<.1	<.1	<.1	<.2	<.2	<.3	<.2	<.1	<.1	<.1	<.4	<.1
1501 E. Lycoming	<.1	<.2	<.1	<.2	<.2	<.2	<.2	<.1	<.1	<.1	<.3	<.1
500 S. Broad	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.1	<.4	<.1
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	1.0	.5	.4	.9	1.1	1.0	.8	.4	.4	.2	2.0	.3
Minimum	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
Average^b	<.2 (92)	<.1 (82)	<.1 (92)	<.2 (90)	<.2 (93)	<.2 (86)	<.2 (92)	<.1 (90)	<.1 (89)	<.1 (84)	<.4 (84)	<.1 (84)
1967												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	< .8	.3	<.2	<.2	<.2	<.1	<.1	<.1	<.1	<.1	<.1	<.1
1501 E. Lycoming	1.0	.3	<.2	<.2	<.2	<.1	<.1	<.1	<.1	<.1	<.1	<.1
500 S. Broad	<1.6	.3	<.2	<.2	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.2
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	20.8	.7	.6	.4	.5	.2	.2	.1	.2	1.0	.3	.8
Minimum	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
Average^b	<1.2 (90)	<.3 (81)	<.2 (90)	<.2 (82)	<.1 (82)	<.1 (89)	<.1 (92)	<.1 (92)	<.1 (85)	<.1 (86)	<.1 (82)	<.1 (81)
1968												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	.3	.3	.3	.4	.3	<.2	.3	.2	.2	<.2	<.1	<.2
1501 E. Lycoming	.4	.4	.4	.4	<.3	<.3	.3	.2	.2	<.2	<.1	<.2
500 S. Broad	.4	.3	.3	.3	.3	<.2	.3	.2	.2	<.1	<.1	<.1
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	1.1	.7	.7	.7	.5	.6	.5	.4	.5	.3	.3	.5
Minimum	<.1	<.1	<.1	.1	<.1	<.1	.1	<.1	<.1	<.1	<.1	<.1
Average^b	.4 (76)	.3 (81)	.3 (91)	.4 (70)	.3 (83)	<.3 (89)	.3 (89)	.2 (90)	.2 (75)	<.2 (77)	<.1 (77)	<.2 (83)

Table 2. Gross beta radioactivity in surface air,[a] Philadelphia, August 1961 to December 1971—continued

Sampling by station & year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1969												
Average gross beta radioactivity per station (pCi/m^3):												
3200 Frankford	<.2	.2	.2	.2	.4	.5	.4	.5	.4	<.2	<.1	<.1
1501 E. Lycoming	<.2	<.2	.2	.3	.4	.5	.4	.5	.4	.2	<.2	<.1
500 S. Broad	<.2	.1	<.2	.3	.4	.5	.4	.5	.3	<.2	<.1	<.2
Air surveillance, all Philadelphia stations, gross beta (pCi/m^3):												
Maximum	.3	.3	[illegible]	.5	1.0	1.3	.8	1.0	.6	.3	.3	.9
Minimum	<.1	<.1	<.1	<.1	<.1	<.1	.1	.1	.2	<.1	<.1	<.1
Average[b]	<.2 (78)	.1 (78)	.2 (79)	.3 (80)	.4 (91)	.5 (77)	.4 (88)	.5 (89)	.4 (86)	<.2 (88)	<.1 (84)	<.1 (79)
1970												
Average gross beta radioactivity per station (pCi/m^3):												
3200 Frankford	<.1	.2	.2	.4	.5	.7	.5	.5	.2	.2	(c)	(c)
1501 E. Lycoming	<.1	.2	.3	.4	.6	.6	.5	.5	.3	.2	<.3	<.2
500 S. Broad	<.1	.2	<.2	.4	.5	.6	.5	.4	.2	<.2	<.2	<.2
Air surveillance, all Philadelphia stations, gross beta (pCi/m^3):												
Maximum	.3	.5	.5	1.0	1.2	1.1	1.0	.8	.7	.4	.8	.8
Minimum	<.1	<.1	<.1	.1	.2	.3	.1	.2	<.1	<.1	<.1	<.1
Average[b]	<.1 (87)	<.2 (77)	<.2 (90)	.4 (90)	.5 (87)	.6 (82)	.5 (83)	.5 (85)	.3 (82)	.2 (85)	<.2 (59)	<.2 (60)
1971												
Average gross beta radioactivity per station (pCi/m^3):												
1501 E. Lycoming	<.1	<.2	.3	.6	.7	.7	.6	.6	<.2	<.2	<.2	<.2
500 S. Broad	<.1	<.1	<.2	<.4	<.6	.5	.5	.3	<.2	<.2	<.1	<.1
Air surveillance, all Philadelphia stations, gross beta (pCi/m^3):												
Maximum	.2	.5	.6	1.4	1.4	1.3	1.4	1.1	.4	.5	.3	.4
Minimum	<.1	<.1	<.1	<.1	<.1	.1	<.1	<.1	<.1	<.1	<.1	<.1
Average[b]	<.1 (50)	<.2 (50)	.3 (60)	.5 (47)	.6 (61)	.6 (57)	.6 (52)	.5 (54)	<.2 (51)	<.2 (58)	<.1 (58)	<.2 (58)

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[a] Analysis 1 day after removal of filter up to May 31, 1962; 4 days after removal from June 1, 1962 through October 12, 1966; 3 or 5 days after removal from October 31, 1966.

[b] Figure in parenthesis indicates number of samples represented in average.

[c] Discontinued.

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Table 3. Average radioactivity in raw surface water (pCi/liter) Philadelphia, 1958–1962

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1958												
New York Ship Delaware River:												
Gross gamma							*11.5 (9)	18.2 (9)	12.8 (9)	23.0 (9)	45.5 (9)	30.9 (9)
1959												
USPHS (7)												
Philadelphia composite:												
Suspended										4	<1	0
Dissolved										4	<1	0
1960												
New York Ship Delaware River:												
Gross gamma	[b] 44.1	18.1	58.0	43.9	35.3	13.9	11.4	18.6	14.8	19.0	21.2	14.7
USPHS (7) Philadelphia composite:												
Suspended	3	3	0	0	0	1	0	0	0	0	0	3
Dissolved	0	4	3	3	<1	0	0	6	0	0	0	3
1961												
New York Ship Delaware River:												
Gross gamma	6.3	16.3	11.0	11.3	13.2	12.0		$\bar{x}$ = 13.5		12.0	23.8	16.8
Torresdale Filter Plant Delaware River:												
Gross beta								2.1	5.8	9.5	28.4	44.0
Queen Lane Reservoir Schuylkill River:												
Gross beta								7.1	4.7	5.5	11.4	38.1
USPHS (7) Philadelphia composite:												
Suspended	0		0	1	0	9	5	0	1	7		13
Dissolved	0		0	0	0	0	6	4	3	14		22
1962												
New York Ship Delaware River:												
Gross gamma	17.3	20.2	16.4	13.4	$\bar{x}$ = 19.1			$\bar{x}$ = 24.0			$\bar{x}$ = 23.7	
Torresdale Filter Plant Delaware River:												
Gross beta	68.9	48.0	47.5	29.5	13.8	16.2	12.6	13.7	14.6	10.7	19.6	23.2
Gross gamma	146.0	87.6	49.9	55.4	32.8	10.7	22.1	44.6	23.9	26.3	44.7	40.4
Queen Lane Reservoir Schuylkill River:												
Gross beta	30.3	60.3	31.9	27.6	16.2	15.7	7.4	14.0	9.9	7.8	15.9	15.2
Gross gamma	56.7	51.3	45.8	31.0	35.9	43.8	19.0	19.5	56.7	23.2	16.9	30.5
USPHS (7) Philadelphia composite:												
Suspended	31	10	22	23	5	6	4	9	5	5	16	15
Dissolved	37	18	21	24	12	14	22	13	14	15	24	33

*1959 New York Ship, gross beta annual average 26 1.
**Philadelphia, Ben Franklin Bridge (3).
3/8/59–5/1/60, 10 samples, gross beta $\bar{x}$ = 20, range 3–45 pCi/liter.
***Philadelphia Naval Shipyard (3).
3/8/59–1/10/60, 9 samples, gross beta $\bar{x}$ = 30, range 2–105 pCi/liter.

See footnotes at end of table.

Table 3. Average radioactivity in raw surface water (pCi/liter) Philadelphia, 1958–1962—continued

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1963												
Delaware River:												
New York Shipbuilding:												
Gross gamma	43.9	84.5	92.2	38.7	42.1	12.5	40.2	37.2	37.8	29.3	24.2	32.7
Torresdale Filter Plant:												
Gross beta	33.0	92.2	63.6	20.1	56.6	16.2	25.1	19.0	18.5	15.0	17.5	21.0
Gross gamma	42.5	116.0	74.1	44.8	157.0	31.3	33.3	29.8	21.8	38.3	82.8	55.2
Schulykill River; Queens Lane Reservoir:												
Gross beta	31.8	51.9	66.7	22.6	32.1	26.9	24.4	23.9	24.7	12.1	4.2	12.7
Gross gamma	87.6	28.5	94.5	16.2	76.4	51.6	31.2	47.3	26.2	74.1	52.9	63.9
Delaware River:												
Station #6 (Navy Yard):												
Gross beta:												
Suspended	* <1	<1	5	<1	<1	<1	7	<1	<1	<1	<1	<1
Dissolved	*3	14	14	17	10	9	350	17	9	8	7	7
Gross alpha, dissolved				(2)								
Station #7 (Wharton St):												
Gross beta:												
Suspended (pCi/mg)	* <1	<1	10	<1			4	<1	<1	<1	<1	<1
Dissolved	*7	44	15	13			16	7	9	28	10	7
Gross alpha, dissolved										(8)		
Station #9 (Lehigh Ave):												
Gross beta:												
Suspended	* <1	<1	3	1	<1		<1	<1	<1	6	<1	<1
Dissolved	*3	18	11	11	22		14	9	5	7	8	6
Gross alpha, dissolved				(2)								
USPHS Philadelphia composite sample:												
Suspended	23	—	64	—	19	16	11	5	8	17	4	7
Dissolved	59	—	39	—	30	32	24	20	18	16	13	12
1964												
Delaware River:												
New York Shipbuilding:												
Gross gamma	21.5	24.4	23.8	16.7	13.6	13.8	17.7	13.3	18.3	17.9	15.1	15.7
Torresdale Filter Plant:												
Gross beta	11.2	4.8	5.6	11.2	13.7	—	—	0	13.7	0	6.1	5.5
Gross gamma	83.4	37.3	2.9	27.4	178.0	—	—	59.7	61.8	62.7	6.4	54.5
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta	13.0	18.5	6.2	23.2	13.7	—	—	4.6	2.3	<1.0	5.1	25.3
Gross gamma	83.9	43.0	19.2	49.3	132.0	—	—	25.0	44.8	35.3	52.8	40.9
Delaware River:												
Station #6 (Navy Yard):												
Gross beta:												
Suspended	<1	<1	—	<1	1	<1	—	—	—	—	—	—
Dissolved	8	4	—	8	15	9	11	6	6	8		
Gross alpha, dissolved					2			1	1	3		
Station #7 (Wharton St):												
Gross beta:												
Suspended	<1	<1	—	<1	<1	<1	—	—	—		—	
Dissolved	8	4	—	7	15	10	32	6	7	7	—	
Gross alpha:												
Dissolved							4		1	2		
Station #9 (Lehigh Ave):												
Gross beta:												
Suspended	<1	<1	—	<1	<1	<1	—		—	—	—	—
Dissolved	8	5	—	9	16	8	13	6	9	7	—	—
Gross alpha:												
Dissolved							2	1	3	2		
USPHS Philadelphia composite sample:												
Suspended	20	15	13	14	10	0	5	5	1	1	7	2
Dissolved	13	11	9	11	8	12	15	11	7	8	10	5

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1965												
Delaware River:												
New York Shipbuilding:												
Gross gamma	14.3	19.7	14.8	8.4	10.4	16.2	9.3	5.9	7.8	9.8	6.5	[d]7.3
Torresdale Filter Plant:												
Gross beta:												
Suspended	11.9	21.2	* .2	6.6	3.2	9.2	.1	.2	2.3	1.6	4.5	2.0
Dissolved		—	* .7	7.2	9.6	9.1	0	1.3	3.0	1.5	10.7	3.9
Gross gamma	27.0	—										
Schulykill River:												
Queens Lane Reservoir:												
Gross beta:												
Suspended	12.1	24.6	* .5	10.0	3.0	8.8	.9	1.4	6.1	2.2	2.9	2.8
Gross gamma:												
Dissolved	47.6	—	* .6	7.1	3.0	9.5	1.7	0	.1	.9	7.6	1.2
Delaware River:												
Station #6 (Navy Yard):												
Gross beta:												
Suspended	<1	<1	<1	<1	<1	<1						
Dissolved	13	8	8	9	9	9	Discontinued by NERHL			([f])	[f] <1	[f] 1.0
Gross alpha:												
Dissolved	1	3	2	3	3	86	Discontinued by NERHL			([f])	[f] 5.6	[f] 4.3
Station #7 (Wharton St):												
Gross beta:												
Suspended	<1	<1	<1	<1	<1	<1					.6	1.2
Dissolved	6	8	8	9	6	7	Discontinued by NERHL			([f])	7.3	1.6
Gross alpha:												
Suspended												
Dissolved		4		2	3	60	Discontinued by NERHL			([f])	1.2	
Station #9 (Lehigh Ave):												
Gross beta:												
Suspended	<1	<1	<1	—	<1	<1					3.6	2.5
Dissolved	8	19	7	—	5	6	Discontinued by NERHL			([f])	2.1	5.4
USPHS Philadelphia composite sample:*												
Suspended	29	3	4	3	1	1	1	2	2	2	1	2
Dissolved	6	7	6	6	4	7	8	8	10	6	5	4
*(Sampling discontinued in December 1965)												
1966												
Delaware River:												
Torresdale composite:												
Gross beta												
Suspended											<1.7	<1.0
Dissolved											<3.4	<1.9
Torresdale filter plant:												
Gross beta:												
Suspended	3.3	7.3	3.3	1.9	0	1.5	.4	2.3	1.8	.3	[a] <1.0	<1.0
Dissolved	2.3	4.9	3.1	.2	2.5	2.2	3.2	1.7	[illegible]	.5	9.2	<3.1
Gross alpha:												
Dissolved											<1.0	<1.6
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	2.5	2.5	1.1	5.5	.3	3.0	0	2.7	1.3	1.0	<1.0	<1.0
Dissolved	3.3	2.6	2.0	1.2	1.3	3.3	5.1	7.8	.5	<.1	<8.3	<1.0
Delaware River:												
Station #6 (NE sewage treatment plant):												
Gross beta:												
Suspended	.5	4.0	3.0	.7	2.2	5.8	.2	.3	3.1	.1	<1.0	<1.0
Dissolved	2.8	2.1	6.8	2.8	2.2	6.4	3.3	.8	1.2	.3	<5.4	<2.3
Station #7 (Wharton St):												
Gross beta:												
Suspended	.3	1.7	4.0	3.5	2.7	2.1	2.9	.4	1.3	.1	<1.0	<1.0
Dissolved	1.7	1.9	4.2	2.3	1.6	4.6	4.8	6.3	5.4	<.4	<5.6	<2.0
Station #9 (Lehigh Ave):												
Gross beta:												
Suspended	1.1	3.2	4.9	.8	2.8	4.4	1.1	2.8	1.3	.6	<1.0	<1.0
Dissolved	1.7	1.3	3.0	1.9	4.8	2.8	3.2	5.8	2.9	.4	<4.2	<2.3
Gross alpha:												
Suspended												<.5
Dissolved											<1.0	

See footnotes at end of table.

Table 3. Average radioactivity in raw surface water (pCi/liter) Philadelphia, 1958–1962—continued

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
USPHS Philadelphia composite sample:												
Suspended	5	0	3	4	—	—	1					3
Dissolved	6	5	6	3	—	—	5					5
1967												
Delaware River:												
Torresdale composite:												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.5	<1.1	<1.5	<1.0	<1.3	<1.0	<1.0	<1.0	<1.0
Dissolved	<2.2	<1.0	<1.0	<2.6	<1.1	<1.1	<2.0	<1.6	<1.2	<1.8	<1.0	<1.7
Gross alpha:												
Suspended			[a] <.6		[a] <1.2	[a] <.8						
Torresdale filter plant:												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.5	<1.4	<4.7	<1.0	<1.5	<1.0	<1.0	<1.0	<1.3
Dissolved	<3.5	<1.0	<1.9	<1.7	<1.4	<1.1	<1.7	<3.2	<1.4	<3.5	<2.0	<3.1
Gross alpha:												
Suspended				<.5		<.7						
Dissolved	[b] <1.6	<1.0								<.5	<.6	<.7
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.8	<1.4	<1.0	<1.0	<1.5	<1.0	<1.0	<1.0	<1.0
Dissolved	<3.1	<1.0	<1.5	<5.2	<1.0	<1.0	<1.1	<2.4	<2.0	2.8	<1.0	3.8
Gross alpha:												
Suspended					<2.1			<.5				
Delaware River:												
Station #6 (NE sewage treatment plant):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.1	<2.8	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	<1.6	<1.0	<1.0	<1.2	<1.2	<1.0	<1.8	<1.6	<1.2	<1.6	<1.0	<1.6
Gross alpha:												
Suspended					<3.1	<.6	<.9					
Dissolved					<.6							
Station #7 (Wharton St):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<4.5	<1.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	<1.8	<1.0	<1.0	<3.9	<1.3	<1.0	<2.0	<1.2	<1.9	<1.8	<1.0	<1.1
Gross alpha:												
Suspended	<.5				<.7							
Station #9 (Lehigh Ave):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<2.3	<4.8	<1.0	<1.5	<2.3	<1.0	<1.0	<1.0	<1.0
Dissolved	<2.7	<1.0	<1.2	<1.3	<1.2	<1.2	<5.3	<5.1	<1.9	<1.6	<1.0	<1.4
Gross alpha:												
Suspended			<.5		<5.2							
Dissolved					<.6						<.6	
USPHS Philadelphia comp site sample:												
Suspended	1	1	1	0	0	0	0	0		0	0	0
Dissolved	5	3	0	0	0	0	0	1		0	0	0
1968												
DelawareRver:												
Torresdale composite:												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	<5.6	<1.7	<1.0	<1.0	<1.1	<1.5	<1.0	<1.7	<2.3	<2.6	<2.4	<1.8
Torresdale filter plant:												
Gross beta:												
Suspended	<5.5	<1.0	<1.8	<1.0	<1.0	<1.4	<1.0	<1.0	<1.0	<1.0	<1.1	<1.0
Dissolved	<6.6	<1.3	<1.0	<1.0	<1.2	<1.6	<1.0	<1.5	<3.2	<3.5	<5.2	<4.6

Gross alpha:												
Suspended	----	----	<.5									
Dissolved	<.5	<2.0	<.6	----	----	----	----	----	<.6	<.5	<1.1	<1.3
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	<2.9	<1.0	<1.0	<1.0	<3.1	<1.7	<1.0	<1.0	<1.0	<2.7	<1.0	<1.0
Dissolved	4.2	<1.9	<1.0	<1.0	<1.7	<2.4	<1.7	<2.1	<3.0	<3.7	3.5	4.2
Delaware River:												
Station #6 (NE sewage treatment plant):												
Gross beta												
Suspended	<1.4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.4	<1.0
Dissolved	<3.1	<1.6	<1.0	<1.0	<1.0	<1.8	<1.0	<1.5	<2.0	<2.4	<2.6	<2.1
Gross alpha:												
Suspended	<.6	----	----	----	----	----	----	----	----	----	<.5	
Station #7 (Wharton Street):												
Gross beta:												
Suspended	<1.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	<3.4	<1.0	<1.0	<1.0	<1.2	<1.0	<1.0	<1.3	<2.7	<2.7	2.3	2.3
Station #9 (Lehigh Avenue):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.1	<1.2
Disso ved	<2.7	<2.0	<1.0	<1.0	<1.2	<1.4	<1.4	<1.6	<3.0	<2.8	<2.6	2.3
Gross alpha:												
Suspended	----	----	----	----	----	----	----	----	----	<.5		
1969												
Delaware River:												
Torresdale composite:												
Gross beta:												
Suspended	<1.0	<1.0	<1.3	<1.1	<1.1	<1.1	<1.1	<2.4	<1.1	<1.0	<1.0	<1.2
Dissolved	<1.8	<2.3	<3.0	<2.1	1.6	2.6	2.6	2.8	2.8	2.2	1.8	2.3
Gross alpha:												
Suspended	----	----	----	----	----	----	----	<.5				
Torresdale filter plant:												
Gross beta:												
Suspended	<1.0	<1.0	<1.1	<1.0	<1.8	<1.0	<1.0	<1.6	<1.7	<1.3	<1.5	<1.3
Dissolved	2.4	<2.0	3.2	<2.1	<8.4	2.6	3.2	3.7	5.3	3.0	3.4	3.4
Gross alpha:												
Suspended	----	----	----	----	----	----	----	<.6	<.6	----	----	<.5
Dissolved	<1.3	----	----	----	<.5	----	----	<1.0	<1.9	<.9	<.9	<.5
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<3.1	<1.0	<1.0	<1.1	<1.2
Dissolved	<2.9	<1.3	3.6	<1.9	3.1	<2.1	4.0	<3.0	2.7	2.9	2.2	2.1
Gross alpha:												
Dissolved	----	----	----	----	----	----	----	<.5				
1969												
Delaware River:												
Station #6, (NE sewage treatment plant):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.1	<1.0	<1.0	<1.0	<1.1
Dissolved	<2.7	5.3	4.6	2.7	2.3	3.8	<3.0	3.3	4.0	2.9	2.8	2.4
Gross alpha:												
Suspended	----	----	----	----	----	----	----	----	----	<.5		
Station #7 (Wharton Street):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.7	<1.0	<1.0	<1.0	<1.2
Dissolved	2.2	2.9	3.5	2.8	2.1	2.9	2.7	3.2	3.0	<2.3	2.4	2.2
Station #9 (Lehigh Avenue):												
Gross beta:												
Suspended	<1.0	<1.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.5	<1.0	<1.0	<1.0	1.0
Dissolved	<2.6	2.7	3.3	2.5	5.3	8.3	7.9	6.3	7.6	4.2	2.4	2.6
Gross alpha:												
Suspended	----	----	----	----	----	----	----	<.6				
Dissolved	----	----	----	----	<1.6	<2.2	<1.8	<1.7	<1.5	<.7	----	<.8

See footnotes at end of table.

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Table 3. Average radioactivity in raw surface water (pCi/liter) Philadelphia, 1958–1962—continued

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1970												
Delaware River:												
Torresdale composite:												
Gross beta:												
Suspended	<1.4	<1.6	<1.0	<1.0	<2.8	<1.0	<1.4	<1.6	<1.0	<1.1	<1.0	<1.0
Dissolved	2.9	2.7	2.9	2.4	2.0	2.5	2.0	2.3	2.0	3.5	2.2	2.1
Gross alpha:												
Suspended		<.5			<.5					<.5		
Torresdale filter plant:												
Gross beta:												
Suspended	<1.3	<1.0	<1.8	<3.8	<1.4	<1.0	<1.0	<1.0	<1.3	<1.6	<1.0	<1.7
Dissolved	3.2	2.5	2.7	2.7	2.7	3.8	3.0	5.7	2.8	4.3	3.8	3.1
Gross alpha:												
Suspended				<.5				<.5				
Dissolved					<.5		<.7	<.6	<.7	<1.0	<2.4	<.9
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	<1.0	<1.2	<1.0	<1.1	<1.5	<1.0	<1.0	<1.0	<1.0	<2.4	<8.0	<1.0
Dissolved	2.9	3.0	3.3	3.7	2.6	3.5	2.9	3.4	<2.5	4.9	4.8	3.3
Gross alpha:												
Suspended				<.6							<.7	
Delaware River:												
Station #6 (NE sewage treatment plant):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.1	<1.0	<2.2	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	3.8	3.8	3.6	2.8	3.3	2.6	3.2	3.0	2.5	3.7	1.9	2.1
Gross alpha:												
Suspended								<.5				
Dissolved								<.6				
Station #7 (Wharton Street)												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.4	<1.0	<2.3	<1.0	<1.9	<1.4	<1.0	<1.0
Dissolved	2.5	2.3	2.8	2.2	<2.1	2.6	2.3	3.6	3.9	4.1	2.7	2.2
Gross alpha:												
Dissolved								<.7	<1.6	<.5		
Station #9 (Lehigh Avenue):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	2.6	<2.0	3.2	2.4	<2.1	2.9	2.6	3.2	2.6	4.3	3.9	2.0
Gross alpha:												
Suspended				<.5								<1.5
Dissolved										<.6		
1971												
Delaware River:												
Torresdale composite:												
Gross beta:												
Suspended	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.3	<1.0	<1.0	<1.7	<1.2
Dissolved	2.2	2.3	<1.3	1.5	2.3	2.0	<2.5	<2.5	2.7	3.1	<1.4	<1.5
Gross alpha:												
Suspended		<.5							<.5			
Torresdale filter plant:												
Gross beta:												
Suspended	<1.3	<1.6	<3.2	<1.5	<3.6	<2.6	<1.8	<2.2	<1.1	<1.0	<2.1	<3.0
Dissolved	<4.3	3.0	2.3	<1.6	1.9	2.4	<2.1	3.0	4.1	4.7	<2.4	2.8
Gross alpha:												
Suspended					<.6				<.5		<.7	
Dissolved	<.8							<.7				<.7
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	<1.0	<1.0	<1.4	<1.0	<1.0	<1.0	<1.0	<1.4	<1.0	<1.0	<1.3	<1.0
Dissolved	2.9	2.1	2.1	2.7	<3.2	3.2	3.5	<1.6	<2.5	3.6	<2.4	2.2
Gross alpha:												
Suspended											<.5	<.6
Delaware River:												
Station #6 (NE sewage treatment plant):												
Gross beta:												
Suspended	<1.0	<1.8	<1.0	<1.0	<1.0	<1.0	<1.0	<1.8	<1.0	<1.0	<1.8	<1.2

Dissolved	2.3	2.7	<1.4	<1.3	1.2	2.4	<2.0	2.0	3.3	<3.1	<1.3	<1.4
Gross alpha:												
Suspended	...	...	...	...	...	...	...	<.5	<.5			
Station #7 (Wharton Street):												
Gross beta:												
Suspended	<1.0	<1.4	<1.0	<2.2	<1.0	<1.0	<1.0	<1.8	<1.0	<1.0	<1.9	<1.0
Dissolved	<2.1	<1.5	<1.3	<1.4	<1.3	2.6	<2.2	<1.5	<2.8	<2.5	<1.6	1.7
Gross alpha:												
Dissolved	...	...	...	...	...	...	...	<.9				
Station #9 (Lehigh Avenue):												
Gross beta:												
Suspended	<1.0	<2.2	<1.1	<1.0	<1.0	<1.2	<1.0	<1.4	<1.0	<1.0	<1.6	<1.1
Dissolved	<2.0	<2.3	<1.5	1.6	1.5	<1.7	<1.6	2.9	3.1	3.4	<1.6	<1.5
Gross alpha:												
Suspended	...	...	...	...	...	...	<.5					
Dissolved	...	...	...	...	...	<.8						

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[a] New York Shipbuilding Corporation averaged the results from daily samplings, July 1958 through December 1958.

[b] New York Shipbuilding Corporation averaged the results from weekly composite samples from January 1959.

[c] Stations 6, 7, and 8 established January 1, 1963. Analysis by Northeast Radiological Health Laboratories. If not reported, gross alpha was less than 1 pCi/liter dissolved or less than 1 pCi/mg of suspended material within a sample.

[d] Discontinued.

[e] Torresdale and Queen's Lane Stations discontinued gross beta and gamma and initiated beta radioactivity suspended and dissolved analysis.

[f] Stations 6, 7 & 9 reinstituted by Philadelphia in November 1965. Station #6 sampling site changed to N.E. Sewage Treatment plant in November 1965.

[g] Initiated wide beta counter October 17, 1966. Analysis for gross beta and gross alpha as suspended and dissolved radioactivity. All alphas were <0.4 pCi/liter unless indicated.

[h] Gross alpha in pCi/liter. If not reported, alpha was less than 0.4 pCi/liter after January 1967.

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Table 4. Average radioactivity in precipitation, process water and milk (pCi/liter) Philadelphia, 1961—1971

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1961												
Precipitation:												
Number of samples								2	1	2	4	3
Total depth (inches)								3.42	2.41	1.83	2.04	2.78
Gross beta								14	138	516	2,824	1,472
Gross gamma											2,610	707
Tap water:												
Gross beta								5.4	6.0	5.2	23.8	19.8
Milk pasteurized:[c]												
Average gross beta										[a] 568	691	592
Iodine-131										[b] 14.6	123	100
1962												
Precipitation:												
Number of samples	1	5	4	4	3	3	2	4	3	4	2	2
Total depth (inches)	2.95	3.51	3.91	3.69	1.85	7.40	2.30	6.58	2.77	.95	4.60	2.11
Gross beta	1,295	1,790	1,398	784	1,345	1,260	1,225	477	940	2,053	1,424	994
Gross gamma	877	1,423	732	543	851	793	1,320	784	1,114	2,540	1,862	1,233
Tap water:												
Gross beta	20.3	19.5	24.5	15.3	10.1	10.1	9.6	7.4	14.3	7.8	10.1	10.1
Milk pasteurized:[c]												
Average gross beta	953	660	875	438	967	734	763					
Iodine-131	88	70	71	72	114	<10.0	<12.1	<20.4	172	92.0	88.4	<46.8
1963												
Precipitation:												
Number of samples	2	1	3	1	3							
Total depth (inches)	2.31	2.19	3.94	1.13	1.06	2.88	3.13	3.35	6.44	.09	6.67	1.76
Gross beta	2,215	1,629	1,393	2,814	1,618							
Gross gamma	1,852	1,630	1,340	4,604	1,573							
Tap water:												
Gross beta	15.1	24.5	27.7	19.8	24.7	15.8	14.4					
Milk pasteurized:[c]												
Average gross beta	762	580	600	395	783	431						
Iodine-131	<10.0											
1964												
Precipitation:												
Total depth (inches)	3.92	2.83	1.94	5.27	.47	.21	3.83	.49	2.42	1.73	1.64	5.13
1965												
Precipitation:												
Total depth (inches)	2.35	2.18	3.19	2.33	1.23	2.85	3.22	4.05	3.02	2.02	1.05	1.85
Milk pasteurized:												
Average concentrations:												
Strontium-89 and strontium-90	11.0	9.0			14.3	13.7	13.5	5.0	7.3			
Strontium-90										20.4	17.8	15.1
Iodine-131	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Yttrium-90										11.0	11.4	17.5
1966												
Precipitation:												
Total depth (inches)	2.82	4.30	.68	4.35	2.95	.41	2.35	1.63	8.70	5.12	2.36	4.33
Gross alpha:												
Suspended											<.4	<.4
Dissolved											<1.1	<.9
Tap water:												
Gross beta:												
Lycoming											[d] <3.2	[d] <5.8
Broad											<2.2	<2.2
Milk pasteurized:												
Average concentrations:												
Strontium-89 and strontium-90						14.4	15.7	18.0	12.2			
Strontium-89											<13.7	12.8
Strontium-90	16.4	14.8	12.3	10.2	10.8					17.2	17.4	<22.8
Iodine-131	<10.0	<10.0	<10.0	<10.0	<10.0	16.6	14.0	<10.0	<10.0	<10.0	<10.0	—
Yttrium-90	15.2	15.0	13.6	9.0	10.5	10.9	12.5	11.6	16.8			

See footnotes at end of table.

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Table 4. Average radioactivity in precipitation, process water and milk (pCi/liter) Philadelphia, 1961—1971—continued

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1967												
Precipitation:												
Number of samples	2	4	6	4	5	4	8	7	3	1	2	6
Total depth (inches)	1.67	1.82	4.53	2.17	3.49	4.12	7.11	7.08	2.96	2.00	1.99	5.88
Gross beta:												
Suspended	194.4	<12.1	<6.0	<5.1	<8.7	<1.5	<1.5	<1.0	<1.0	<1.0	<3.6	<104.1
Dissolved	20.5	40.8	24.6	46.3	23.9	9.0	<6.1	<3.8	<3.9	4.2	24.2	77.3
Gross alpha:												
Suspended	<.4	<.5	<.4	<.4	<4.5	<.6	<.4	<.4	<.4	<.4	1.4	<.4
Dissolved	<.7	<.8	<.4	<.4	<5.9	<.5	<.4	<.9	<.4	<.4	1.0	<.5
Tap water:												
Gross beta:												
Lycoming	<2.1	<1.0	<1.4	<1.0	<1.4	<1.0	<1.0	<2.9	<1.2	<1.2	<1.0	<1.7
Broad	<3.4	<1.0	<1.0	<2.3	<1.3	<1.0	<1.1	<5.6	<1.6	<1.4	<1.4	<3.1
Milk pasteurized:												
Average concentrations:												
Strontium-89	<5.0	<5.2	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.1	<5.5	<5.0	<5.0
Strontium-90	25.3	15.0	14.2	14.0	9.4	15.4	14.5	7.3	15.2	17.8	<12.8	<14.6
Iodine-131	<15.3	<10.0	<10.0	<17.5	13.6	<16.4	<10.0	<11.8	<10.0	<10.0	<10.0	<10.0
1968												
Precipitation:												
Number of samples	3	1	6	1	5	4	2	1	2	3	8	4
Total depth (inches)	2.90	1.40	4.98	1.57	5.17	5.89	2.00	1.24	.44	3.15	4.17	2.54
Gross beta:												
Suspended	<26.6	2.5	<2.8	2.0	46.8	5.3	<10.9	5.0	3.4	<1.1	<3.1	<8.3
Dissolved	38.9	34.2	21.4	16.2	54.6	12.0	32.0	36.7	17.8	8.0	13.3	18.4
Gross alpha:												
Suspended	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4
Dissolved	<.4	5.4	<.6	<.4	<.4	<.4	<.4	<.4	<.8	<.4	<.8	<1.9
Tap water:												
Gross beta:												
Lycoming	<2.2	<1.2	<1.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.9	<2.0	<2.6	<1.6
Broad	<2.7	<2.0	<1.5	<1.0	<1.0	<1.1	<1.0	<1.6	<2.3	<2.7	<3.3	2.8
Milk pasteurized:												
Average concentrations:												
Strontium-89	<5.0	<5.0	<5.0	<6.2	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<6.9
Strontium-90	10.9	13.8	<8.3	<12.1	14.6	<9.6	<6.0	<13.2	9.5	8.6	<7.2	<17.2
Iodine-131	<10.0	<10.0	<10.0	<11.2	<10.8	—	<10.0	<10.0	<10.0	<10.0	<10.0	<10.8
1969												
Precipitation:												
Number of samples	5	3	3	5	4	5	8	4	3	3	2	5
Total depth (inches)	1.57	1.88	1.92	1.68	3.30	7.31	8.33	2.66	4.38	1.13	1.97	7.23
Gross beta:												
Suspended	<2.7	<3.3	2.3	10.2	5.5	<5.1	<7.3	6.0	<3.1	<2.7	3.6	<2.9
Dissolved	12.1	12.1	18.0	30.9	24.5	39.0	46.8	21.1	18.9	8.4	15.5	<4.2
Gross alpha:												
Suspended	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.6	<.6	<.4
Dissolved	<.9	<.4	<.4	<.4	<.4	<.4	<.4	<.8	<.7	<.9	<.7	<.4
Tap water:												
Gross beta:												
Lycoming	2.7	2.3	2.8	<1.8	1.8	2.0	2.2	2.6	<2.5	<2.3	2.1	2.2
Broad	<5.3	2.6	2.2	<1.6	2.2	2.1	2.8	2.4	<2.2	<2.3	2.9	2.1
Milk paseturized:												
Average concentrations:												
Strontium-89	<6.0	<5.0	—	<7.1	8.2	<7.2	14.3	<5.0	—	6.4	—	—
Strontium-90	<8.9	<5.0	—	<6.1	<7.2	<6.4	<5.7	<11.6	<7.0	11.1	25.6	—
Iodine-131	<10.5	<10.0	18.8	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.2	<10.0
1970												
Precipitation:												
Number of samples	2	4	6	4	4	4	5	1	2	2	5	4
Total depth (inches)	.74	2.08	3.83	6.12	2.57	1.60	2.75	3.99	.82	3.66	4.71	5.27
Gross beta:												
Suspended	<1.6	<5.7	9.2	6.8	20.7	13.0	<4.8	5.4	9.5	1.3	<2.6	<1.0
Dissolved	6.5	14.7	43.1	27.2	60.2	93.6	31.7	10.8	18.1	9.3	9.6	<6.5
Gross alpha												
Suspended	<.4	<.4	<.5	<.4	<.5	<.4	<.6	<.4	<.4	<.6	<.5	<.4
Dissolved	<.4	<.4	<.4	<.4	<.7	<.5	<.4	1.3	< .4	<.4	<.6	<.6
Tap water:												
Gross beta:												
Lycoming	2.1	2.0	2.0	2.0	<2.4	2.1	2.2	2.8	2.5	2.5	2.0	2.5
Broad	2.6	2.0	2.7	<1.9	2.5	2.7	2.3	3.2	1.9	3.3	2.1	2.2
Milk pasteurized:												
Average concentrations:												
Strontium-90	18.6	13.4	<6.6	7.0	11.2	8.6	<7.8	<5.2	<8.2	10.0	• <2.0	2.8
Iodine-131	<10.0	<10.0	<10.0	<10.2	<10.0	<10.0	<10.0	<10.0	—	<10.0	<10.0	<10.0

See footnotes at end of table.

Table 4. Average radioactivity in precipitation process water and milk (pCi/liter) Philadelphia, 1961—1971—continued

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1971												
Precipitation:												
Number of samples	3	6	3	2	4	1	2	4	5	4	5	3
Total depth (inches)	2.13	5.43	2.58	1.84	4.10	1.01	4.81	9.61	5.83	3.84	5.37	1.21
Gross beta:												
Suspended	<2.9	<2.6	6.6	62.5	52.2	22.5	1.6	7.9	<1.0	<1.5	<3.0	<1.3
Dissolved	26.0	10.1	15.9	58.2	33.8	19.5	10.0	<3.9	2.8	6.5	<5.7	11.2
Gross alpha:												
Suspended	.4	.4	.4	.4	.4	.4	.4	.8	.4	.4	.4	.4
Dissolved	1.1	.4	.4	.4	.4	.4	.4	.5	.4	.6	.4	.7
Tap water:												
Gross beta:												
Lycoming	<2.4	2.9	<2.0	<1.4	<1.6	1.2	1.7	<1.8	2.3	<1.9	<1.7	1.5
Broad	6.4	2.2	1.7	<1.9	2.3	2.2	<2.4	2.1	2.6	<1.8	2.6	2.2
Milk pasteurized:												
Average concentrations:												
Strontium-90		5.1	5.5	<6.8	<20.0	<14.7	6.2	6.6	<6.2	7.9	7.1	<3.8
Iodine-131	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0

[a] Gross beta radioactivity assessment was initiated in October 1961. The technique involved evaporating 20 ml of raw milk to dryness in a crucible and combusting at 600° C. for 3 hours to remove organic constituents. The residue was taken up in nitric acid, transferred to a planchet, the nitric acid evaporated and the planchet counted.

[b] Determined by the Jefferson Medical College radiation laboratory using resin extraction technique and a 3-inch NaI (T1) crystal.

[c] Discontinued.

[d] After November 1966 gross alpha radioactivity was <0.4 pCi/liter in each sample for Lycoming and Broad stations except: Broad—December 1968, <0.6, January 1969, <0.5; and August 1970, <0.5; Lycoming—August 1970, <0.7; October 1970, <0.5; and December 1970, <1.3.

[e] MDA reduced from 5 pCi/liter to 2 pCi/liter.

[f] This sample was not the same as the PHS pasteurized milk network sample (9).

If the iodine-131 iodide ion test indicated greater than 10 pCi/liter, the milk was analyzed for strontium-90, strontium-89, barium-140 and lanthanide radioactivity. If the iodine-131 iodide test indicated less than 10 pCi/liter, only the strontium-90 determination of whole milk was completed.

A dual ion exchange column is used for the analysis of strontium-90. Yttrium is removed by an anion exchange resin, eluted with HCl and precipitated with oxalic acid. The minimum detectable activity for strontium-90 was 5 pCi/liter until October 1970. Beginning in December 1970, the minimum detectable activity was reduced to 2 pCi/liter by increasing counting time. The practical reporting level has been continued at 5 pCi/liter. If the iodide test indicates a concentration greater than 10 pCi/liter of iodine-131, a lanthanum extraction procedure is used between successive precipitations of yttrium oxalate. The standard deviation of replicate analysis of strontium-90 by this ion exchange procedure has consistently been ±1.5 pCi/liter or ±5 percent whichever is greater.

REFERENCES

(1) TERRILL, JR., J. G. PHS participation in the operation of the N.S. Savannah, summary report for the period, 1962–1963. Presented May 17, 1963 hearing by the Division of Licensing and Regulation, USAEC, Germantown, Md.

(2) GOLDIN, A. S. and P. F. HALLBACH. Delaware River surveillance report of progress, January 1-July 31, 1959. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

(3) STRAUB, C. P. and P. F. HALLBACH. Delaware River surveillance, report of progress, January 1, 1959-June 30, 1960. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

(4) CAHILL, D. F. The Delaware River surveillance project, July 1-December 31, 1960. Division of Radiological Health, Special Projects Branch, Montgomery, Ala.

(5) KAUFFMAN, P. E. The Delaware River surveillance project, December 1, 1960-December 31, 1961. Division of Radiological Health, Technical Operations Branch, Montgomery, Ala.

(6) WYERMAN, T. A., R. K. FARNSWORTH, and G. L. STEWART. Tritium in streams in the United States, 1961–1968, Table 7, p. 428. Radiol Health Data Rep 11:421–439 (September 1970).

(7) FEDERAL WATER POLLUTION CONTROL ADMINISTRATION. Gross radioactivity in surface waters of the United States, December 1967. Radiol Health Data Rep 9:306–307 (June 1968).

(8) LIEBERMAN, J. and M. H. GREEN. Radioactivity in Philadelphia environment, August 1, 1961-July 31, 1963. Occupational and Radiological Health Report, Department of Public Health, Philadelphia (1963).

(9) ENVIRONMENTAL PROTECTION AGENCY and FOOD AND DRUG ADMINISTRATION. Milk surveillance, October 1972. Radiat Data Rep 14:88 (February 1973).

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Joint Dental Radiation Survey In Puerto Rico, 1968

Michael Gileadi [1,2]

The objective, scope, and methods used in the 1968 Joint Dental Survey Project, sponsored jointly by the Health Department of Puerto Rico Nuclear Center and School of Dentistry, University of Puerto Rico, are described. Health hazards associated with dental x-ray diagnostic procedures in Puerto Rico in 1968 are evaluated, and relevant statistical and technical data pertinent to the use of x rays in the dental profession on the Island are presented.

Puerto Rico—the smallest island of the Great Antilles, with an area of approximately 3,500-square miles and a population of 2,739,100 in 1968—has undergone a tremendous economic and social development during the past 30 years.

Along with a general improvement in health care, the annual rate of dental x rays taken on the island increased significantly. Highlights of statistical data relating to dental radiography in Puerto Rico during 1968, are presented in figure 1 (*1*, *2*).

Because of the nature of x radiation, dental radiography, while indispensable as a diagnostic tool in modern dentistry, at the same time, is unavoidably accompanied by certain health hazards. The primary purpose of the Joint Dental Radiation Survey Puerto Rico–1968, was to evaluate the health hazards associated with dental radiography in frequency as well as in magnitude.

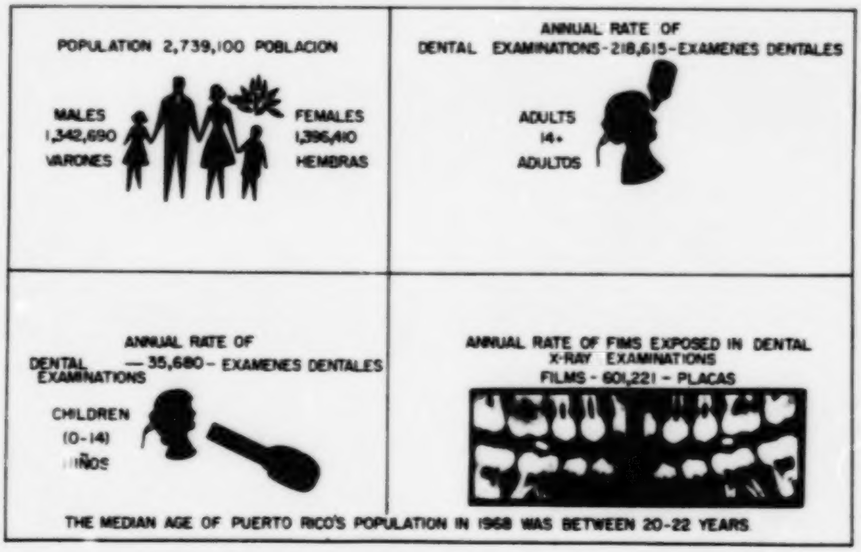
POPULATION 2,739,100 POBLACION
MALES
1,342,690
VARONES
FEMALES
1,396,410
HEMBRAS
ANNUAL RATE OF
DENTAL EXAMINATIONS - 218,615 - EXAMENES DENTALES
ADULTS
14+
ADULTOS
ANNUAL RATE OF
DENTAL EXAMINATIONS — 35,680 - EXAMENES DENTALES
CHILDREN
(0-14)
NIÑOS
ANNUAL RATE OF FIMS EXPOSED IN DENTAL X-RAY EXAMINATIONS
FILMS - 601,221 - PLACAS
THE MEDIAN AGE OF PUERTO RICO'S POPULATION IN 1968 WAS BETWEEN 20-22 YEARS

Figure 1. Statistical data highlights relating to dental radiography in Puerto Rico during 1968

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[2] The responsibility for radiation protection and control (associated with the use of radiation in medicine, education, and commerce in Puerto Rico) rests with the Radiological Health Program in the Department of Health, Commonwealth of Puerto Rico.

The frequency of the health hazard is characterized by the annual rate of dental x-ray examinations, while the magnitude of the effect is described by the gonadal dose associated with each procedure considered.

Indices selected for quantitating the health hazards associated with dental x-ray diagnostic each procedure are:

1. per capita per annum exposure
2. per capita per annum gonadal dose.

Since the magnitude of the unintentional dose delivered during dental radiographies to the patient (and also to dental personnel) is related to the technical parameters of the dental x-ray unit used for radiography, a detailed study was made on all operative dental x-ray units and their technical characteristics (7). Significant results of this study are presented in tables 1 through 3 and figures 2 and 3. Table 1 indicates the number of operative dental x-ray units by type of medical facility in Puerto Rico, 1968.

Table 1. Reported number of operative dental x-ray units by medical facility, Puerto Rico, 1968

Medical facilities with dental x-ray unit	Public institutions	Private offices	Total	Percent
1	36	340	397	90
2	7	26	33	7.4
3 or more	4	7	11	2.6
Grand total	47	373	441	100

Figure 2 shows distribution of operative dental x-ray units in Puerto Rico by year of installation from 1940 to 1968. From figure 2, it is learned that in 1940, with a population of 1,869,255, there were 16 operative dental x-ray units in Puerto Rico. In 1968, with a population of 2,739,100, the number of operative dental x-ray units on the island was 441. This is to say, that between 1940 and 1968, the number of dental x-ray units increased 27.5 times. Presented in a form standardized for population, this corresponds to an increase from .88 units per 100,000 population in 1940 to 24.5 units per 100,000 population in 1968; i.e., close to a 28-fold increase. The population per dentist and per operative x-ray unit in Puerto Rico is presented in table 2.

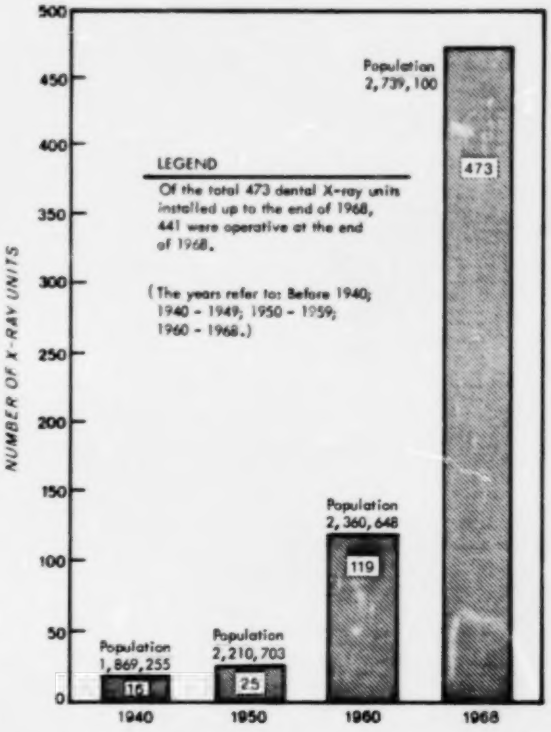

Figure 2. Distribution of operative dental x-ray units by year of installation (from 1940 to 1968)

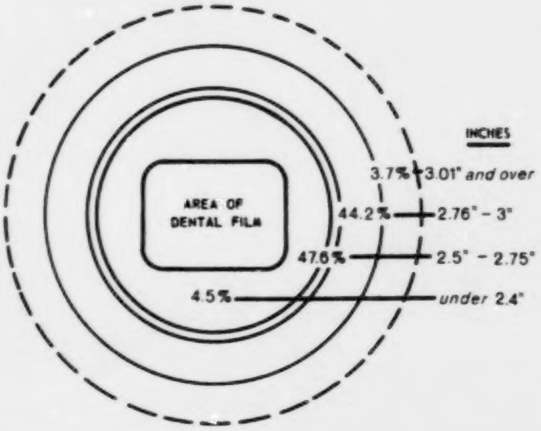

Figure 3. Distribution of dental x-ray units by beam diameter, Puerto Rico, 1968

Table 2. Distribution of dental x-ray units in public institutions and private offices by geographic location, population per dentist and population per dental x-ray unit, Puerto Rico, 1968

Geographic location* and population	Number of public institutions with dental x-ray units	Number of operative dental x-ray units in public institutions	Number of private offices with operative dental x-ray units	Number of operative dental x-ray units in private offices	Total number of operative dental x-ray units	Total number of practicing dentists	Population per practicing dentist	Population per operating dental x-ray unit
Western region, 416,300	17	8	36	36	44	42	9,911	9,461
Southern region, 493,500	12	3	48	52	55	75	6,580	8,972
Northern areas, Caguas, Fajardo, Arecibo, Bayamon, 1,168,500	21	13	92	99	112	68	17,183	10,433
San Juan metropolitan area, 660,800	19	22	190	208	230	302	2,175	2,873
Puerto Rico, 2,739,100	69	46	366	395	441	487	5,624	6,211

* See figure 4.

Table 3. Distribution of dental x-ray units by cone type Puerto Rico, 1968

Cone type	Number of units	Percent
Short point	361	81.85
Long	39	8.84
Short open	14	3.17
Long open	5	1.13
Others		1.13
Cephal	3	
Panoram	2	
Not available	17	3.89
Total	441	100

Unintentional irradiation accompanying dental radiography endangers primarily the eyes, the facial area and the thyroid. Exposing the eye lens to x rays may cause opacity of the lens and may also be conducive to cataracts. Dr. K. Z. Morgan states that 500–900 fatal thyroid tumors result yearly from dental radiography (*3–4*) in the United States.

Cognizant of the hazard associated with dental x-ray examinations, and realizing that there is no such thing as a "safe" minimum quantity of radiation, all available precautions are taken to reduce the skin exposure and gonadal dose to a minimum compatible with the diagnostic objective.

Among the most available precautions to reduce exposure in radiodentistry are:

1. proper collimation (beam size),
2. proper filtration, and
3. the use of high-speed films, which may reduce the skin exposure by as much as a factor of four.

In table 3, the distribution of dental x-ray units by cone type is presented. The type of the cone is related to the resulting beam aperture. Figure 3 presents the distribution of

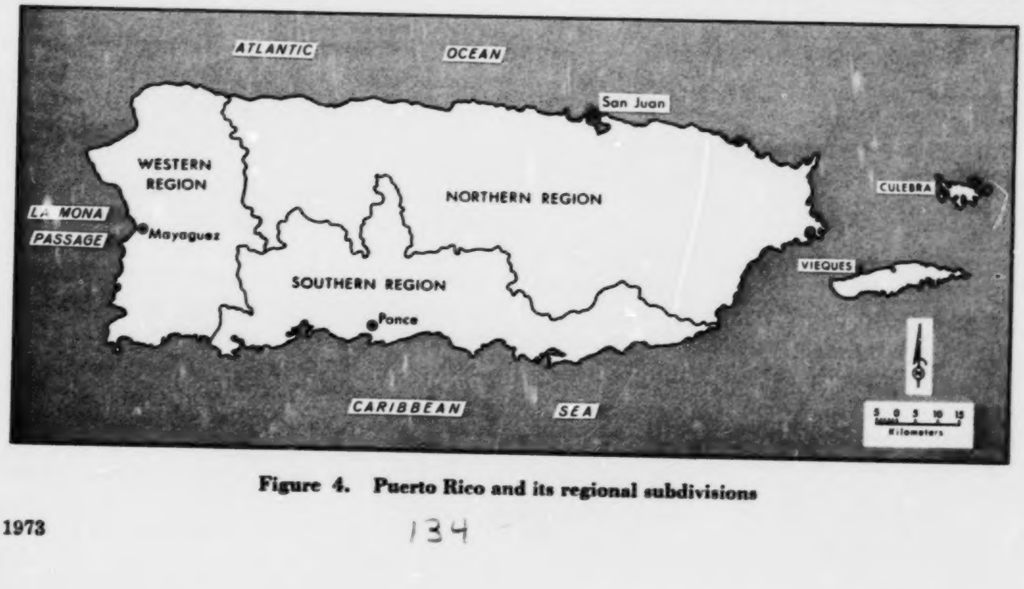

Figure 4. Puerto Rico and its regional subdivisions

Table 4. Annual rate of dental and medical diagnostic total x-ray examinations per 100 population, Puerto Rico, 1968

Geographic location	Population	Annual rate of dental x-ray examinations	Rate of dental x-ray examinations per 100 population	Rate of all x-ray diagnostic examinations per 100 population
Western region	416,300	15,373	3.6	55.3
Southern region	493,500	41,723	8.4	52.5
Northern region (San Juan metropolitan area excluded).	1,168,500	52,553	4.4	43.8
San Juan metropolitan area	660,800	138,154	20.9	98.1
Total	2,739,100	254,295	9.2	60.2

dental x-ray units with respect to beam diameter compared with the actual area of the dental film.

According to the recommendation of the Academy of Oral Roentgenology, as well as the National Council for Radiation Protection (NCRP), the maximum acceptable size of the beam diameter at the film was determined to be 3 inches. According to figure 3, 96.3 percent of all operative dental x-ray units met this limitation in Puerto Rico in 1968. In order to appreciate the progress made, it should be noted that in 1961, only 53.5 percent of all surveyed dental units met the above specification.

In 1968, 82 percent of all dental x-ray units in Puerto Rico had a minimum filtration of 1.5 mm of aluminum equivalent or more.

Most public dental facilities in Puerto Rico use high speed films, as do many private dentists.

Therefore, it can be concluded that the dental radiographic equipment in Puerto Rico meets the standards conducive to proper dental radiation protection practices.

With respect to frequency or annual rate of dental radiographies in Puerto Rico, the survey established, among other things, that:

1. there were 254,295 dental radiographies performed in Puerto Rico in 1968, using over 600,000 dental films (*1*), and
2. these services were rendered by 487 practicing dentists using 441 dental units.

The annual rate of dental x-ray examinations and their rate per 100 population is presented in table 4.

Dosimetric measurements within the framework of the present survey were carried out in the School of Dentistry, University of Puerto Rico, using films, TLD discs, and LiF powder TLD's.

Testicle exposure measurements were carried out in vivo, indicating an average of 3.9 mR exposure for a full mouth dental x-ray examination (14 films) using 65 kV, 10 mA. Table 5 compares the testicle exposures received in full-mouth dental x-ray examinations as determined by various investigations.

Table 5. Testicle exposures due to full-mouth dental x-ray examinations (14 films each) as measured by various investigators

Investigator	Year of publication	(kVp)	(mA)	Average exposure (mR)
Stanford & Vance (*9*)	1955	65	10	4.76
Richards (*6*)	1958	65	10	4.285
Kline et al (*5*)	1970	65	10	5.46
Joint x-ray survey Puerto Rico	1971	65	10	3.86

Table 6 contains the average per capita skin exposure by type of dental radiography and average per capita gonadal dose by type of dental radiography, compiled from published data.

One of the most urgent problems concerning dental care in Puerto Rico is improving the dentist per population ratio. The School of Dentistry of the University of Puerto Rico produces a new generation of highly qualified young dentists for Puerto Rico every year, thus increasing the number of dentists on the Island and at the same time lowering the professional age of dentists and injecting new techniques and ideas into the Island's dental practice.

In order to cope with the ever increasing

Table 6. Average per capita skin and gonadal exposure by type of dental x-ray examination and by sex

Sex	Average per capita skin exposure (mR)			Average per capita gonadal exposure (mR)		
	Single film examination	Full mouth examination	Both types of examination	Single mouth examination	Full mouth examination	Both types of examination
Male	60.29	105.83	166.13	0.02	0.03	0.05
Female	57.21	95.70	152.92	.004	.007	.01
Total	58.72	100.67	159.39	0.01	0.002	0.03

demand for more and better dental care in Puerto Rico, and at the same time, to free the dentists from certain routine tasks, a group of paramedical dental professionals are being educated in the School of Dentistry of the University of Puerto Rico. These include dental assistants, dental hygienists and dental laboratory technicians.

While every dental x-ray procedure is unavoidably associated with certain irradiation hazards, every precaution is being taken in order to reduce these health hazards to a minimum compatible with the medical objective.

The increase of dental tomographies is a case in point, since a dental tomography reduces the exposure rate from the approximately 9,940 mR associated with a 14-film full-mouth examination to about 800–900 mR associated with tomography. It furnishes about the same medical information as a 14 film full-mouth examination. Since 1968, the number of newly installed dental tomographic units has been on the increase, not only in public institutions, but also in private practice, especially in pedodontic facilities.

This is the first comprehensive survey on dental radiography in Puerto Rico. It is hoped that this mutual undertaking by the Department of Health, the Puerto Rico Nuclear Center and the School of Dentistry will provide a useful reference for continued surveillance and protection in the field of dental radiography in Puerto Rico.

REFERENCES

(1) GILEADI, M. Joint Dental Radiation Survey. Commonwealth of Puerto Rico (1973).

(2) DEPARTMENT OF HEALTH, COMMONWEALTH OF PUERTO RICO. Vital Statistics (1968).

(3) MORGAN, K. Z. Never do harm. Environment Magazine (1971).

(4) MORGAN, K. Z. The need for radiation protection. Oak Ridge National Laboratory (1972).

(5) KLINE et al. Dosimetric evaluation of thirty dental facilities in Massachusetts. Oral Surg Med Pathl 29: (1970).

(6) RICHARDS, A. G. Roentgen ray-doses in dental radiography. JADA (May 1958).

(7) ALCOX, R. W. Physical survey manual dental x-ray. DHEW, Bureau of Radiological Health, Rockville, Md. (April 1967).

(8) WUEHRMANN, A. Current concepts on the use of x-ray in dentistry. Bureau of Radiological Health, Rockville, Md. (1970).

(9) STANFORD, R. W. et al. Some problems encountered in the investigation of gonad doses. British J Radiat (June 1962).

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SECTION I. MILK AND FOOD

Milk Surveillance, February 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

137

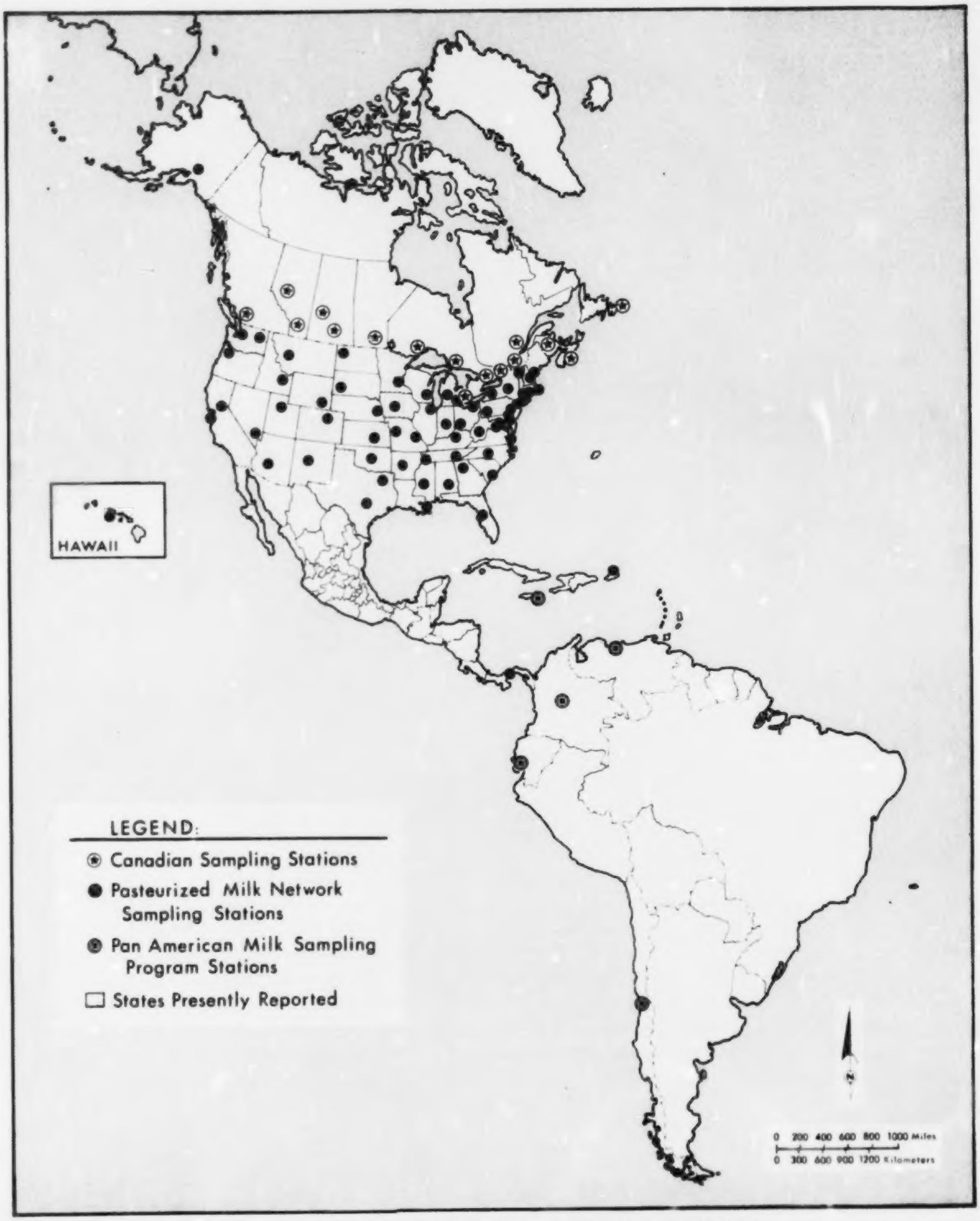
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
☐ States Presently Reported
N
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reported in *Radiation Data and Reports*, 13 participated in this study.

The accuracy results of this study for these 13 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addi-

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131 (96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
Iodine-131 (438 or 444 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137 (53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	5
Cesium-137 (295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89 (29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
Strontium-89 (197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90 (32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
Strontium-90 (150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

tion, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2–standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported in *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown

Table 2. Concentration of radionuclides in milk for February 1973 and 12-month period, March 1972 through February 1973

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	NA	5	0	6
Alaska:	Palmer [c]	P	3	4	0	4
Ariz:	Phoenix [c]	P	NA	0	0	0
Ark:	Little Rock [c]	P	7	9	0	3
Calif:	Sacramento [c]	P	NA	1	0	0
	San Francisco [c]	P	NA	0	0	0
	Del Norte	P	7	11	0	7
	Fresno	P	0	1	0	3
	Humboldt	P	3	3	0	3
	Los Angeles	P	0	1	0	2
	Mendocino	P	2	3	0	4
	Sacramento	P	0	2	0	3
	San Diego	P	0	1	0	4
	Santa Clara	P	10	2	0	3
	Shasta	P	2	2	0	5
	Sonoma	P	2	2	0	4
Colo:	Denver [c]	P	NA	3	0	1
	East	R	NS	NA	NS	4
	Northeast	R	1	NA	NS	1
	Northwest	R	NA		[d] 0	0
	South Central	R	NS	NS	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NS	NA	NS	2
	West	R	NA	NA	0	2
Conn:	Hartford [c]	P	NA	5	0	5
	Central	P	5	7	11	13
Del:	Wilmington [c]	P	NA	8	11	8
D.C:	Washington [c]	P	NA	6	11	4
Fla:	Tampa [c]	P	4	4	23	35
	Central	R	5	5	37	42
	North	R	7	6	13	14
	Northeast	R	6	5	59	34
	Southeast	R	6	5	44	48
	Tampa Bay area	P	6	5	28	34
	West	R	6	8	15	13
Ga:	Atlanta [c]	P	NA	9	15	9
Hawaii:	Honolulu [c]	P	3	2	0	1
Idaho:	Idaho Falls [c]	P	5	4	0	0
Ill:	Chicago [c]	P	7	5	12	8
Ind:	Indianapolis [c]	P	NA	5	0	2
	Central	P	4	7	0	9
	Northeast	P	5	6	0	10
	Northwest	P	7	8	15	11
	Southeast	P	5	7	0	8
	Southwest	P	8	7	10	10
Iowa:	Des Moines [c]	P	NA	4	0	0
	Iowa City	R	6	7	0	7
	Des Moines	P	5	6	0 (3)	4
	Little Cedar	R	5	7	0	6
	Le Mars	R	4	4	0	4
Kans:	Wichita [c]	P	NA	6	0	0
	Coffeyville	P	NA		14	9
	Dodge City	P	NA		6	6
	Falls City, Nebr	R	NS		NS	
	Hays	P	NA		8	6
	Kansas City	P	NA		7	8
	Topeka	P	NA		4	0
	Wichita	P	NA		5	5
Ky:	Louisville [c]	P	NA	7	11	4
La:	New Orleans [c]	P	7	12	0	3
Maine:	Portland [c]	P	NA	6	14	21
Md:	Baltimore [c]	P	NA	6	0	5
Mass:	Boston [c]	P	6	6	13	14
Mich:	Detroit [c]	P	NA	7	0	6
	Grand Rapids [c]	P	NA	7	0	4
	Bay City	P	6	3	0	5
	Charlevoix	P	9	4	0 (4)	7
	Detroit	P	4	3	0	5
	Grand Rapids	P	10	4	0	7
	Lansing	P	8	4	0 (2)	7
	Marquette	P	10	5	0 (2)	15
	Monroe	P	8	2	0 (2)	3
	South Haven	P	10	5	3 (4)	7
Minn:	Minneapolis [c]	P	NA	7	0	12
	Bemidji	P	9	7	12	17
	Duluth	P	13	15	22	25
	Fergus Falls	P	6	7	7	12
	Little Falls	P	13	18	12	38
	Mankato	P	4	5	5	10
	Marshall	P	4	5	0	10

See footnotes at end of table.

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Table 2. Concentration of radionuclides in milk for February 1973 and 12-month period, March 1972 through February 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—continued						
Minn:	Minneapolis	P	7	9	11	13
	Rochester	P	8	7	10	9
Miss:	Jackson [c]	P	NA	9	0	7
Mo:	Kansas City [c]	P	NA	5	0	1
	St. Louis [c]	P	NA	6	0	2
Mont:	Helena [c]	P	NA	4	0	0
Nebr:	Omaha [c]	P	NA	5	0	1
Nev:	Las Vegas [c]	P	NA	1	0	0
N.H:	Manchester [c]	P	NA	8	13	14
N.J:	Trenton [c]	P	NA	7	11	6
N. Mex:	Albuquerque [c]	P	NA	1	0	0
N.Y:	Buffalo [c]	P	5	5	0	4
	New York City [c]	P	NA	8	11	6
	Syracuse [c]	P	NA	6	0	5
	Albany	P	4	5	0 (4)	0
	Buffalo	P	5	6	0	0
	Massena	P	NS	7	NS	0
	New York City	P	6	6	0	0
	Syracuse	P	NS	4	NS	0
N.C:	Charlotte [c]	P	NS	8	NS	6
N. Dak:	Minot [c]	P	NA	9	0	5
Ohio:	Cincinnati [c]	P	NA	5	0	4
	Cleveland [c]	P	NA	6	0	5
Okla:	Oklahoma City [c]	P	NA	5	0	2
Oreg:	Portland [c]	P	3	4	0	3
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia [c]	P	NA	6	12	4
	Pittsburgh [c]	P	NA	8	0	8
	Dauphin	P	0	4	0	7
	Erie	P	3	5	0	5
	Philadelphia	P	4	5	0	6
	Pittsburgh	P	5	7	0	9
R.I:	Providence [c]	P	NA	6	12	11
S.C:	Charleston [c]	P	6	8	0	10
S. Dak:	Rapid City [c]	P	NA	5	0	1
Tenn:	Chattanooga [c]	P	NA	8	0	7
	Memphis	P	NA	7	0	1
	Chattagnooga	R	NA	10	0	9
	Clinton	R	NA	9	5 (2)	12
	Fayetteville	P	NA	10	9 (2)	8
	Kingston	P	NA	10	0	5
	Knoxville	P	NA	8	0 (2)	6
	Lawrenceburg	R	NS	8	NS	10
	Nashville	P	NS	8	NS	7
	Pulaski	R	NA	6	7 (2)	6
	Sequoyah	R	NA		NA	
Tex:	Austin [c]	P	NA	2	0	0
	Dallas [c]	P	NA	5	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City [c]	P	5	3	0	3
Vt:	Burlington [c]	P	NA	5	0	9
Va:	Norfolk [c]	P	NA	6	0	6
Wash:	Seattle [c]	P	NA	3	0	1
	Spokane [c]	P	NA	4	0	5
	Benton County	R	NS	1	NS	0
	Franklin County	R	3	1	0	0
	Longview	R	0	4	0	2
	Sandpoint, Idaho	R	7	8	0	8
	Skagit County	R	5	7	0	4
W. Va:	Charleston [c]	P	NA	7	0	5
Wisc:	Milwaukee [c]	P	NA	5	0	5
Wyo:	Laramie [c]	P	NA	2	0	0

See footnotes at end of table.

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Table 2. Concentration of radionuclides in milk for February 1973 and 12-month period, March 1972 through February 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:						
Alberta:	Calgary	P	NA		19	18
	Edmonton	P	NA		15	14
British Columbia:	Vancouver	P	NA		NS	
Manitoba:	Winnipeg	P	NA		12	15
New Brunswick:	Moncton	P	NA		7	8
Newfoundland:	St. John's	P	NA		10	22
Nova Scotia:	Halifax	P	NA		15	14
Ontario:	Ottawa	P	NA		6	9
	Sault Ste. Marie	P	NA		19	21
	Thunder Bay	P	NA		11	18
	Toronto	P	NA		13	9
	Windsor	P	NA		15	7
Quebec:	Montreal	P	NA		5	9
	Quebec	P	NA		10	19
Saskatchewan:	Regina	P	NA		5	11
	Saskatoon	P	NA		5	12
CENTRAL AND SOUTH AMERICA:						
Canal Zone:	Cristobal [c]	P	NA	1	29	13
Chile:	Santiago	P	0	1	0	1
Colombia:	Bogota	P	NS	0	NS	0
Ecuador:	Guayaquil	P	0	0	0	0
Jamaica:	Mandeville	P	NS	2	NS	49
Puerto Rico:	San Juan [c]	P	NA	1	0	2
Venezuela:	Caracas	P	0	1	0	0
PMN network average [e]			5	5	3	5

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Cesium-137: Colorado—25 pCi/liter

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].

NA, no analysis.

NS, no sample collected.

in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for February 1973

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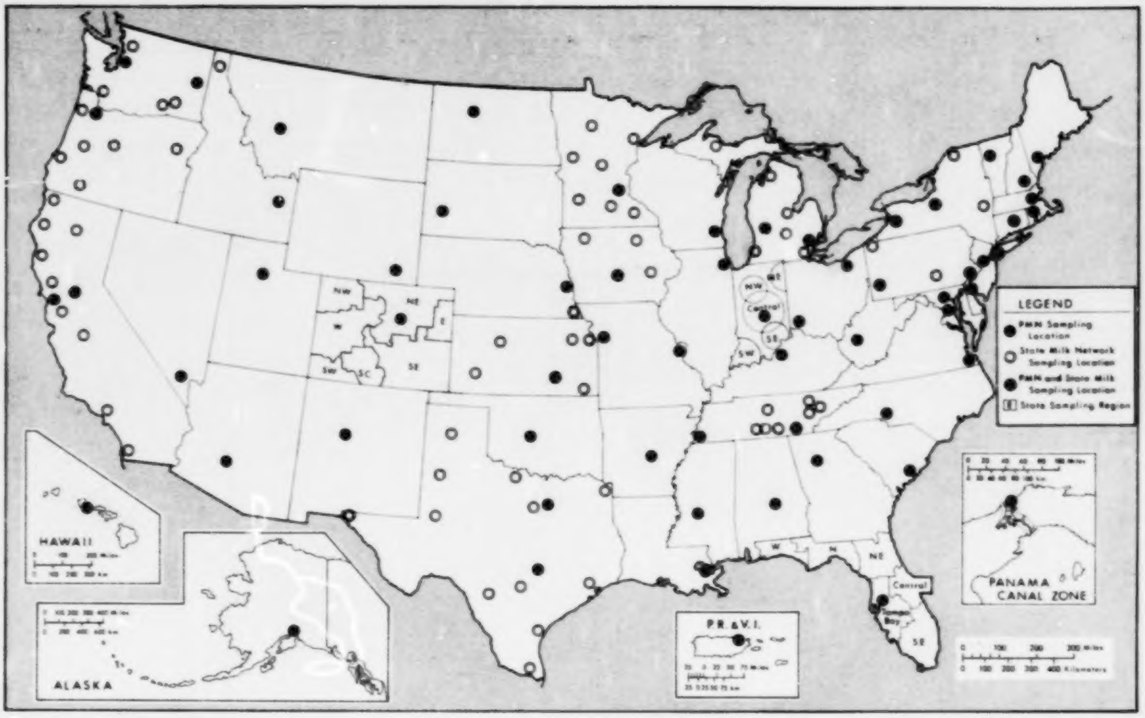
LEGEND
● PMN Sampling Location
○ State Milk Network Sampling Location
● PMN and State Milk Sampling Location
State Sampling Region
NW
NE
W
E
SW
SC
SE
Central
W
N
NE
Central
SE
HAWAII
ALASKA
PR.&V.I.
PANAMA CANAL ZONE

Figure 2. State and PMN milk sampling stations in the United States

and the 12-month period, March 1972 to February 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for February 1973 were below the respective practical reporting levels. No strontium-89, iodine-131, or barium-140 was detected.

Strontium-90 monthly averages ranged from 0 to 10 pCi/liter in the United States for February 1973 and the highest 12-month average was 12 pCi/liter (New Orleans, La.) representing 6.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 59 pCi/liter in the United States for February 1973, and the highest 12-month average was 48 pCi/liter (Southeast Florida) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (7) and Jamaica.

Acknowledgment

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Bureau of Radiological Health
Environmental Health & Consumer
Protection Program
California Department of Public Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
Social and Health Services

REFERENCES

(*1*) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium–90, iodine–131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH, Section I. Milk surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(*4*) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(*5*) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine–131, cesium–137, strontium–89, and strontium–90 measurements in milk, June 1972, Technical experiment 72 MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(*7*) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER and B. KAHN. The cause of relatively high cesium–137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Milk Surveillance Programs, December 1972

National Environmental Research Center—
Las Vegas Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 32 regular and five alternate sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.

In the event of a release of radioactivity from the NTS, special sampling within the affected

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[1] This network is operated under a Memorandum of Understanding (No. AT (26-1)-539 with the Nevada Operations Office, AEC, Las Vegas, Nev.

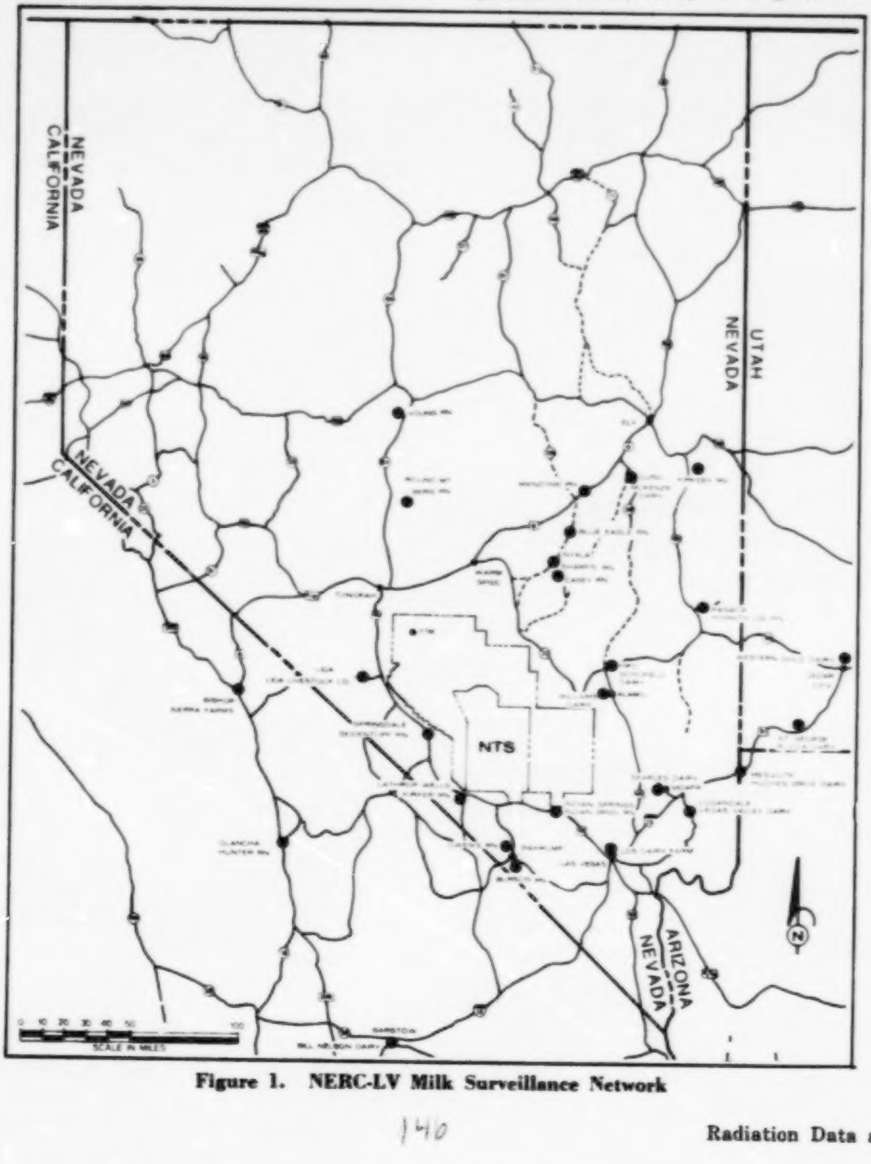
NEVADA
CALIFORNIA
UTAH
NEVADA
NEVADA
CALIFORNIA
ELY
NTS
LATHROP WELLS
PAHRUMP
LAS VEGAS
CEDAR CITY
ARIZONA
NEVADA
BARSTOW
N
0 10 20 30 40 50 100
SCALE IN MILES

Figure 1. NERC-LV Milk Surveillance Network

area is conducted to determine radionuclide concentrations and to take protective action, if required. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the December 1972 issue of *Radiation Data and Reports.*

Results

The analytical results of all milk samples collected in December 1972 by NERC–LV surveillance programs are listed in table 1. With the exception of cesium–137 at levels near the minimum detectable activity (MDA) of 10 pCi/liter, no gamma-emitting fission products were detected in any of the samples by gamma spectroscopy analysis. Levels of tritium and strontium–90 near the MDA's for these radionuclides (~200 pCi/liter and 1 pCi/liter, respectively) were also measured by radiochemistry analyses. Copies of these results were distributed to EPA Regional Offices and appropriate State agencies prior to publication.

Table 1. Milk surveillance results, December 1972

Location	Map number	Date collected (1972)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
California:							
Bishop:							
Sierra Farms	5	12/ 7	11	<10	<3.0	<1.6	NA
Hinkley:							
Bill Nelson Dairy	13	12/ 5	12	<10	<2.0	<.9	NA
Independence:							
Smith Ranch	14	12/ 7	13	<10	<3.0	3.7±1.4	NA
Olancha:							
Hunter Ranch	30	12/ 8	13	<10	<2.0	<1.1	NA
Nevada:							
Alamo:							
Williams Dairy	1	12/ 1	12	<10	<2.0	2.4±1.3	NA
Austin:							
Young's Ranch	3	12/ 1	13	<10	<2.0	3.0±1.4	NA
Belmont:							
Pine Creek Ranch	4	12/ 1	13	40	<3.0	5.1±1.7	NA
Eureka:							
Martin Ranch	10	12/12	13	<10	<3.0	3.5±1.7	NA
Hiko:							
Schofield Dairy	12	12/ 1	12	<10	<2.0	2.8±1.2	<220
Las Vegas:							
Anderson Dairy	17	12/15	11	<10	<2.0	<1.2	NA
Arden Dairy	18	12/15	11	<10	<2.0	<1.1	NA
LDS Dairy Farms	19	12/15	12	<10	<2.0	<1.3	<240
Lida:							
Lida Livestock Company	21	12/ 1	13	<10	<2.0	<1.2	NA
Logandale:							
Vegas Valley Dairy	22	12 /1	12	<10	<2.0	1.2±1.2	NA
Mesquite:							
Hughes Bros. Dairy	25	12/ 1	12	<10	<2.0	<.9	<220
Moapa:							
Searles Dairy	26	12/ 1	12	<10	<2.0	<1.0	NA
Nyala:							
Sharp's Ranch	28	12/ 6	13	<10	<3.0	<1.6	<220
Pahrump:							
Owen's Ranch	31	12/ 1	13	<10	<2.0	1.6±1.2	NA
Panaca:							
Kenneth Lee Ranch	33	12/ 1	13	<10	<2.0	1.9±1.2	NA
Shoshone:							
Kirkeby Ranch	35	12/13	13	<10	<2.0	1.7±1.3	NA
Springdale:							
Seidentopf Ranch	36	12/ 1	13	<10	<2.0	<1.3	NA
Utah:							
Newcastle:							
Newcastle Dairy	27	12/ 1	12	<10	<2.0	1.8±1.2	NA
St. George:							
R. Cox Dairy	37	12/ 1	12	<10	<2.0	1.9±1.2	NA

[a] 11—Pasteurized milk.
12—Raw milk from Grade A producer(s).
13—Raw milk from family cow(s).

[b] Two-sigma counting error provided when available.
NA, not analyzed.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January-June 1971	December 1972
Carbon–14 in Total Diet and Milk	July-December 1971	May 1972
Radiostrontium in Milk	January-December 1971	November 1972
Strontium–90 in Tri-City Diets	January-December 1971	December 1972

Radionuclides in Institutional Diet Samples, January-March 1972

Environmental Protection Agency and
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. Recognizing that the diet is a potentially significant contribution to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is now administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Office of Food Sanitation, Food and Drug Administration, Department of Health, Education, and Welfare (*1*).

This program estimates the dietary intake of radionuclides in a selected population group, ranging from children to young adults of school age. At present 26 institutions (distributed geographically as shown in figure 1) are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, but teenage boys consumed 20 percent more food per day (*1, 2*). Extrapolating this information, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

The sampling procedure is generally the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus between-meal snacks) obtained by duplicating the food intake of a different individual daily. Drinking water —which is not included—is also sampled periodically. Each daily sample is kept frozen until the end of the collection period. It is then packed in dry ice and shipped by air to either the National Environmental Research Center, Las Vegas, Nev. or the Eastern Environmental Radiation Facility, Montgomery, Ala. A detailed description of sampling and analytical procedures has already been presented in Radiological Health Data and Reports (*3*).

Results

Table 1 shows the analytical results for in-

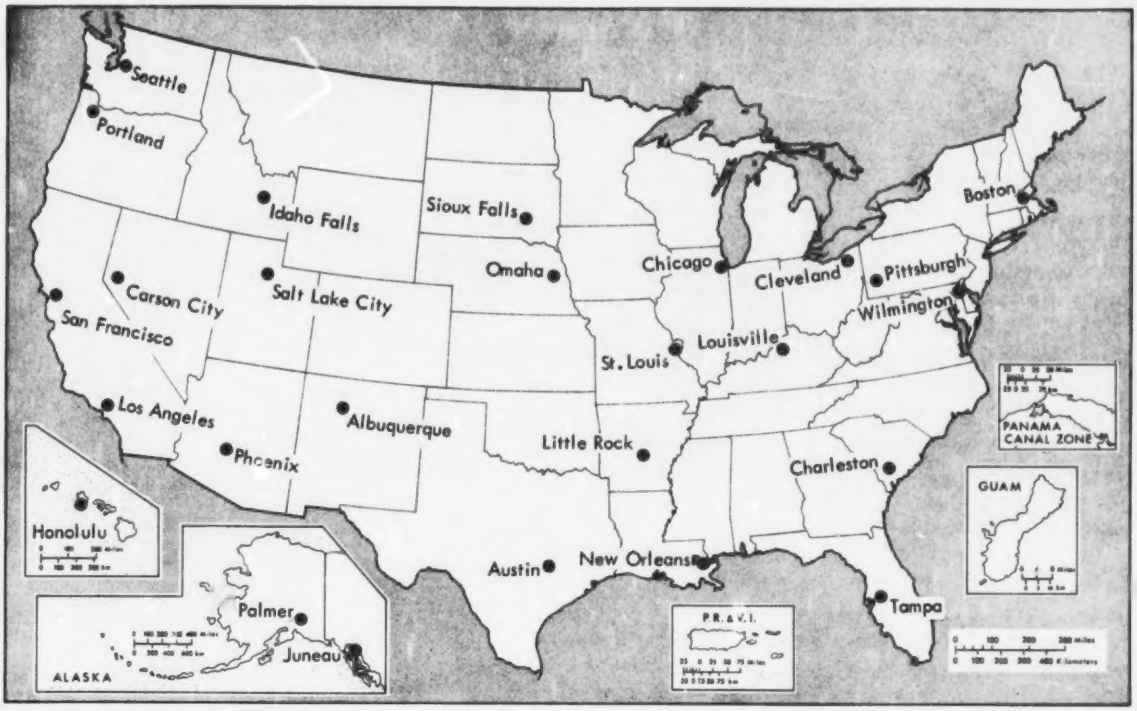
Seattle
Portland
Idaho Falls
Sioux Falls
Omaha
Chicago
Cleveland
Pittsburgh
Boston
Wilmington
Carson City
Salt Lake City
San Francisco
St. Louis
Louisville
Los Angeles
Albuquerque
Little Rock
Phoenix
Charleston
PANAMA CANAL ZONE
GUAM
Honolulu
Austin
New Orleans
Palmer
Juneau
ALASKA
P.R. & V.I.
Tampa

Figure 1. Institutional diet sampling locations as of March 1972

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children January-March 1972

Location of Institution		Month[a]	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
				(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau	Jan	1.57	0.6	0.9	1.9	2.9	4	6	56	88
	Palmer	Jan	1.94	.5	1.0	1.7	3.3	14	27	56	108
Ariz:	Phoenix	Feb	1.76	.7	1.2	1.7	3.0	4	6	0	0
Ark:	Little Rock	Jan	1.73	.7	1.2	1.9	3.2	10	17	14	24
Calif:	Los Angeles	Jan[b]	1.41	.3	.4	1.3	1.9	2	3	0	0
	San Francisco	Jan[b]	1.62	1.0	1.7	2.1	3.5	3	5	0	0
Del:	Wilmington	Feb	1.38	.7	.9	1.0	1.4	5	7	12	17
Fla:	Tampa	Jan	.93	.4	.4	1.4	1.3	5	5	21	20
Hawaii:	Honolulu	Jan	2.24	.5	1.1	1.4	3.2	5	10	0	0
Idaho:	Idaho Falls	Jan[b]	1.52	.9	1.3	1.7	2.6	14	22	20	30
Ill:	Chicago	Jan	.34	.4	.1	1.7	.6	4	1	24	8
Ky:	Louisville	Jan[b]	1.73	.7	1.2	1.6	2.8	7	12	0	0
La:	New Orleans	Jan[b]	1.10	.4	.4	1.9	2.1	6	6	16	18
Mass:	Boston	Mar	2.47	.6	1.5	1.4	3.5	4	9	17	42
Mo:	St. Louis	Jan[b]	1.14	1.0	1.1	1.9	2.2	5	5	0	0
Nebr:	Omaha	Jan	2.59	1.0	2.5	1.4	3.7	6	16	0	0
Nev:	Carson City	Jan	1.36	.8	1.0	1.5	2.1	4	6	0	0
N. Mex:	Albuquerque		NS								
Ohio:	Cleveland	Jan[b]	1.36	.6	.8	1.6	2.2	10	14	22	30
Oreg:	Portland	Jan[b]	1.76	.5	.9	1.8	3.2	3	5	13	23
Pa:	Pittsburg	Jan[b]	2.89	.3	1.0	1.3	3.6	5	14	0	0
S.C:	Charleston	Jan[b]	1.08	.6	.7	1.3	1.4	7	8	0	0
S. Dak:	Sioux Falls	Jan[b]	1.19	.8	.9	1.6	2.0	6	7	0	0
Tex:	Austin	Jan[b]	1.75	.8	1.4	1.6	2.9	6	10	0	0
Utah:	Salt Lake City	Jan[b]	1.96	.5	1.0	1.4	2.7	2	5	0	0
Wash:	Seattle	Feb[b]	2.00	.5	1.0	1.6	[illegible]	5	11	0	0
Institutional average			1.63	0.6	1.0	1.6	2.5	6	10	11	16

[a] Quarterly sample usually collected the first month of the quarter.

[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.

Note: Iodine-131, barium-140, and strontium-89 were not detected at any station during this period.

NS, no sample.

stitutional diet samples collected from all stations during January-March 1972. The stable elements, calcium and potassium, are reported in g/kg of diet. Where applicable, radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.63 kg/day compared to the network average of 1.85 kg/day observed from 1961 through 1971.

Strontium-90 dietary intake averaged 6 pCi/day during this period. Cesium-137 intake averaged 11 pCi/day. These results fall within Range I as defined by the former Federal Radiation Council (*4*). Strontium-89, barium-140, and iodine-131 concentrations were below detectable levels.

All concentrations less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard-deviation analytical error. Accordingly, the minimum detectable limits are strontium-89, 5 pCi/kg; strontium-90, 2 pCi/kg; iodine-131, 10 pCi/kg; barium-140, 10 pCi/kg; and cesium-137, 10 pCi/kg.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-March 1971	September 1971
April-June 1971	November 1971
July-September 1971	April 1972
October-December 1971	June 1972

REFERENCES

(*1*) ANDERSON, E. C., D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Pub Health 52:1391-1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January-March 1965. Radiol Health Data Rep 6:548-554 (October 1965).

(*3*) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January-March 1968. Radiol Health Data Rep 9:557-560 (October 1968).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January-December 1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January-December 1971	February 1973
Michigan	January-June 1970	November 1971
Minnesota	July 1970-June 1971	November 1972
New York	July-December 1970 and January-June 1971	May 1972
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	July-December 1971	November 1972
Tritium Surveillance System	October-December 1972	May 1973
Washington	July 1969-June 1970	March 1972
Water Surveillance Programs, *NERC–LV*	November 1972	May 1973

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Water Surveillance Programs, December 1972

National Environmental Research Center—
Las Vegas, Environmental Protection Agency

The Water Surveillance Network,[1] operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 90 sampling locations (figures 1 and 2) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.

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[1] This network is operated under a Memorandum of Understanding (No. AT (26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

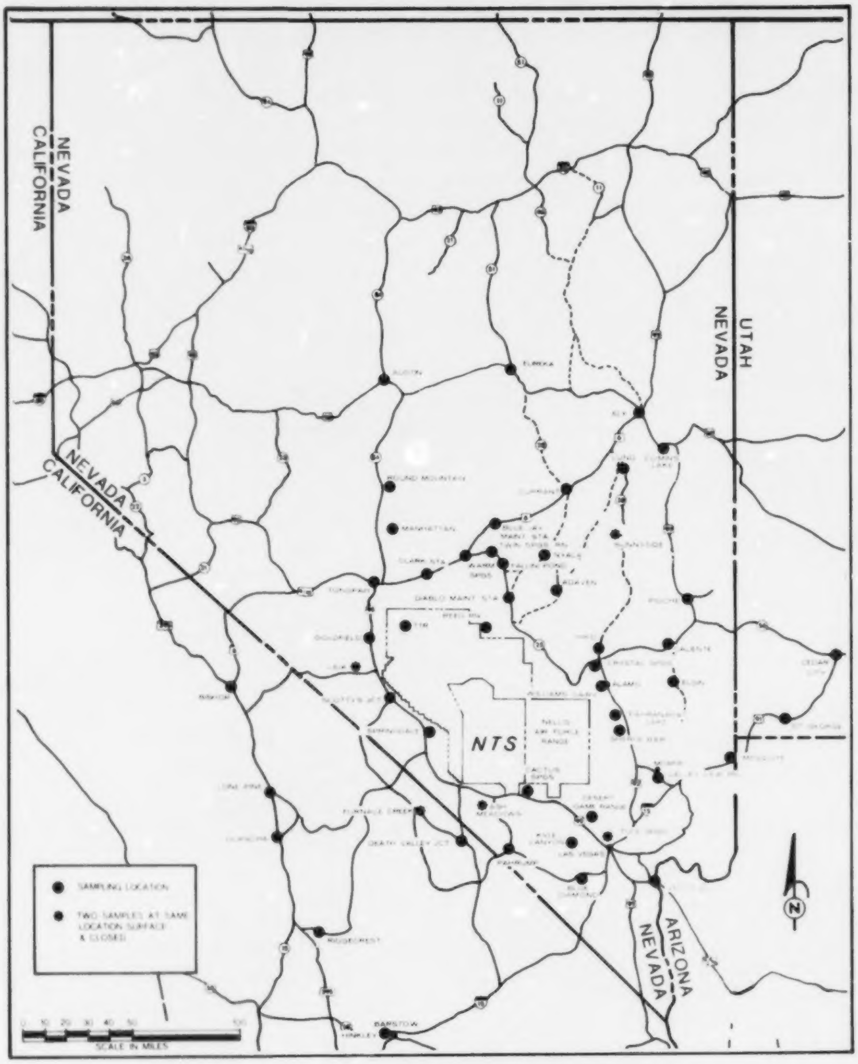
NEVADA
CALIFORNIA
UTAH
NEVADA
NEVADA
CALIFORNIA
ARIZONA
NEVADA
AUSTIN
EUREKA
ELY
LUND
COMINS LAKE
ROUND MOUNTAIN
CURRANT
MANHATTAN
BLUE JAY MAINT STA
TWIN SPGS RN
NYALA
CLARK STA
WARM SPGS
ADAVEN
SUNNYSIDE
TONOPAH
DIABLO MAINT STA
REED RN
TTR
GOLDFIELD
PIOCHE
HIKO
CALIENTE
CRYSTAL SPGS
ALAMO
ELGIN
LIDA
CEDAR CITY
WILLIAMS CANY
PAHRANAGAT LAKE
SCOTTYS JCT
SPRINGDALE
NTS
NELLIS AIR FORCE RANGE
ST GEORGE
MESQUITE
MOAPA
CACTUS SPGS
BISHOP
LONE PINE
FURNACE CREEK
ASH MEADOWS
DESERT GAME RANGE
OLANCHA
DEATH VALLEY JCT
KYLE CANYON
LAS VEGAS
PAHRUMP
BLUE DIAMOND
RIDGECREST
BARSTOW
HINKLEY
● SAMPLING LOCATION
● TWO SAMPLES AT SAME LOCATION SURFACE & CLOSED
0 10 20 30 40 50 100
SCALE IN MILES
N

Figure 1. NERC-LV Water Surveillance Network

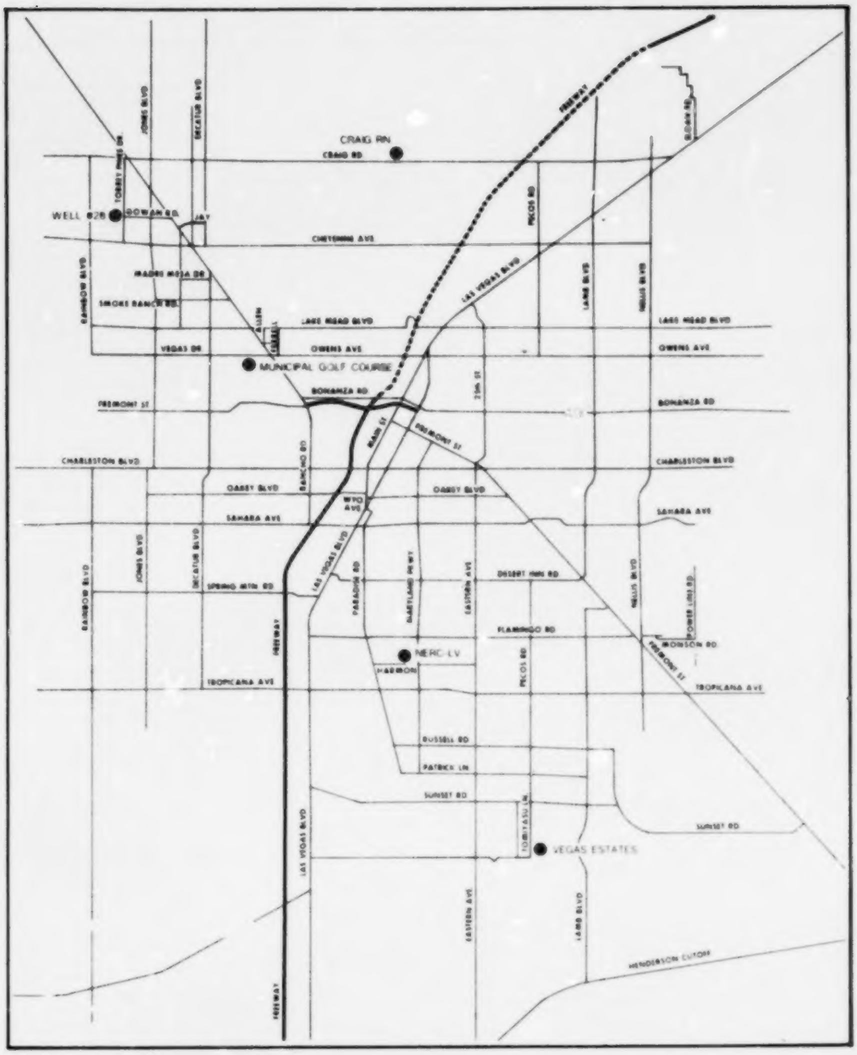
CRAIG RN
CRAIG RD
WELL #28
GOWAN RD
CHEYENNE AVE
LAKE MEAD BLVD
OWENS AVE
VEGAS DR
MUNICIPAL GOLF COURSE
BONANZA RD
FREMONT ST
CHARLESTON BLVD
OAKEY BLVD
SAHARA AVE
SPRING MTN RD
DESERT INN RD
FLAMINGO RD
NERC-LV
HARMON
TROPICANA AVE
RUSSELL RD
PATRICK LN
SUNSET RD
VEGAS ESTATES
HENDERSON CUTOFF
FREEWAY
LAS VEGAS BLVD
RAINBOW BLVD
JONES BLVD
DECATUR BLVD
PECOS RD
LAMB BLVD
NELLIS BLVD
EASTERN AVE
MAIN ST
25th ST

Figure 2. NERC-LV Water Surveillance Network—Las Vegas Valley

In the event of a release of radioactivity from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations and to take protective action, if required. Additional water sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and routine analytical procedures was included with the water results reported in the December 1972 issue of *Radiation Data and Reports*.

For the purpose of identifying the source of the gross radioactivity in all network samples and comparing sample concentrations with both the AEC concentration guides and the PHS Drinking Water Standards, selected samples, from each sampling location are given special analyses at least once a year beginning with calendar year 1972. For surface water samples, the special analyses includes strontium-89, strontium-90, plutonium-238, plutonium-239, uranium, and radium-226.

Table 1. NERC-LV water surveillance results, December 1972—continued

Location	Map number	Data collected	Radioactivity concentration ᵃ (pCi/liter)			
			Sample type ᵇ	Gross alpha	Gross beta	Tritium
California:						
Bishop:						
Fish and Game Office	9	12/ 7	23	<1.1	<3.2	NA
Owens River, 3 miles east	10	12/ 7	22	4.5± 3.8	5.4±3.6	NA
Death Valley Junction:						
Lila's Cafe	21	12/ 8	23	<5.3	7.9±3.7	<240
Furnace Creek:						
Pond	28	12/ 8	21	<3.2	11 ±3.8	NA
Visitors Center	29	12/ 8	27	<3.3	6.1±3.6	NA
Hinkley:						
Bill Nelson Dairy	39	12/ 5	23	11 ± 6.0	6.7±3.5	NA
Little Lake:						
Little Lake Ranch	60	12/ 6	21	16 ± 9.0	26 ±5.0	NA
Lone Pine:						
Diaz Lake	61	12/ 6	21	21 ± 9.6	28 ±4.8	NA
Forest Service Ranger Station	62	12/ 6	23	2.3± 2.0	<3.2	NA
Olancha:						
Haiwee Reservoir	73	12/ 6	21	6.2± 3.6	6.1±3.4	NA
Ridgecrest:						
City Hall	76	12/ 6	23	<3.6	<3.5	NA
Shoshone:						
Chevron Service Station	79	12/ 8	27	<5.0	18 ±4.5	NA
Nevada:						
Adaven:						
Canfield Ranch	1	12/ 5	22	5.6± 3.4	<3.2	NA
Alamo:						
Sheri's Bar	2	12/ 1	23	<2.8	<3.6	NA
Pahranagat Lake	3	12/ 1	21	17 ±.7.9	14 ±4.0	NA
Williams Dairy	4	12/ 1	23	<4.8	9.0±3.7	NA
Ash Meadows:						
Ash Meadows Lodge	5	12/ 1	23	9.0± 6.7	16 ±4.5	<210
Ash Meadows Pond	6	12/ 1	21	19 ± 8.0	21 ±4.6	NA
Austin:						
County Courthouse	7	12/ 1	27	30 ± 7.6	18 ±4.3	NA
Beatty:						
Richfield Service Station	8	12/ 1	23	10 ± 6.6	10 ±4.1	<210
Blue Diamond:						
Post Office	11	12/ 1	23	<3.8	4.8±3.7	<210
Blue Jay Highway:						
Maintenance Station	12	12/ 6	23	3.4± 3.3	<3.2	NA
Cactus Springs:						
Mobil Service Station	13	12/ 1	27	<2.3	<3.5	<210
Caliente:						
Agricultural Extension Station	14	12/ 1	23	3.9± 3.6	4.7 ±3.4	NA
Meadow Valley wash	15	12/ 1	22	5.5± 5.5	14 ±4.0	NA
Clark Station:						
Five Mile Ranch	17	12/ 6	27	<2.1	4.6±3.3	NA
Coyote Summit:						
Sand Spring Well	18	12/ 5	23	34 ± 110	17 ±4.1	NA
Currant Ranch Cafe	20	12/12	27	11 ± 5.0	<3.1	NA
Diablo Highway:						
Maintenance Station	22	12/ 6	23	3.4± 3.2	6.1±3.4	NA
Diablo:						
Reed Ranch	23	12/ 5	21	14 ± 6.0	15 ±4.0	NA
Elgin:						
Water tower	24	12/ 1	23	7.4± 5.5	4.8±3.4	NA
Ely:						
Chevron Service Station	25	12/12	24	2.8± 2.3	3.1±3.1	NA
Eureka:						
Chevron Service Station	27	12/12	24	3.0± 2.9	3.7±3.2	NA
Glendale:						
Chevron Service Station	32	12/ 1	27	<5.2	8.5±3.7	NA
Muddy River	33	12/ 1	22	<5.4	5.7±3.8	NA
Goldfield:						
Alkali Springs	34	12/ 1	21	<4.3	20 ±4.6	NA
Chevron Service Station	35	12/ 1	23	<4.1	9.7±3.7	NA
Hawthorne:						
Walker Lake	36	12/ 1	21	<12	<16	NA
Hiko:						
Crystal Springs	37	12/ 1	27	5.9± 4.2	8.1±3.6	NA
Schofield Dairy	38	12/ 1	23	29 ± 9.1	31 ±4.8	NA
Indian Springs:						
Chevron Service Station	40	12/ 1	23	<2.5	<3.5	<210
Las Vegas:						
Cal-Nev Jet Fuels	41	12/13	23	3.1± 2.7	<3.1	<250
Craig Ranch Golf Course	42	12/13	23	2.6± 2.5	6.4±3.5	380 ±250
Cunningham Ranch	43	12/13	23	<2.2	<3.1	320 ±250
Desert Game Range	44	12/ 1	23	8.9± 4.2	<3.5	<210
Desert Game Range Pond	45	12/ 1	21	<2.7	<3.5	<210
Francis Residence	46	12/13	23	<4.2	<3.2	<250
Lab II, NERC-LV	47	12/14	24	<4.5	5.5±3.4	800 ±260
Lake Mead Vegas Wash	48	12/14	21	<4.5	11.0±3.7	820 ±260

See footnotes at end of table.

Table 1. NERC-LV water surveillance results, December 1972—continued

Location	Map number	Date collected	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
Nevada—continued						
Las Vegas:						
LDS Dairy Farm	49	12/15	23	11.0 ± 7.7	7.7 ±3.7	<250
Lloyd Ranch	50	12/13	23	6.4 ± 5.1	8.3 ±3.6	<250
LV Water District Well 28	51	12/13	23	<2.0	<3.1	<250
Municipal Golf Course	52	12/13	23	3.5 ± 2.8	<3.1	<250
Tule Springs	53	12/ 1	23	2.9 ± 2.7	<3.5	<210
Tule Springs Pond	54	12/ 1	21	5.2 ± 3.3	<3.5	NA
Vegas Estates	55	12/13	23	<4.5	12.0 ±3.9	<250
Lathrop Wells:						
Texaco Service Station	56	12/ 1	23	<2.7	<3.6	<210
Lida Junction:						
Cottontail Ranch	57	12/ 1	23	<3.6	14.0 ±4.0	NA
Lida:						
Lida Livestock Company	58	12/ 1	27	<3.2	<3.3	NA
Pond at storage tank	59	12/ 1	21	4.5 ± 3.9	<3.3	NA
Lund:						
Gardner Grocery	63	12/11	23	3.4 ± 2.7	<3.1	NA
Manhattan:						
Country store	64	12/ 1	23	10.0 ± 6.0	11 ±4.0	NA
Seyler Reservoir	65	12/ 1	21	<3.5	15 ±4.0	NA
Mercury:						
Groom Lake	66	12/ 5	23	6.6 ± 4.0	7.1 ±3.5	NA
Moapa:						
Pederson Valley View Ranch	67	12/ 1	27	7.4 ± 5.9	9.8 ±3.8	NA
Mt. Charleston:						
Kyle Canyon Fire Station	68	12/ 1	27	<2.4	<3.6	<210
Nyala:						
Sharp's Ranch	72	12/ 6	23	2.8 ± 2.7	<3.2	NA
Pahrump:						
Texaco Service Station	74	12/ 1	23	<2.2	<3.5	NA
Pioche:						
County Courthouse	75	12/ 1	24	<2.4	6.1 ±3.7	NA
Round Mountain:						
Mobil Service Station	77	12/ 1	27	<2.2	<3.5	NA
Springdale:						
Peacock Ranch	80	12/ 1	27	<3.2	8.5 ±3.9	<210
Pond	81	12/ 1	21	<4.7	10 ±4.1	NA
Sunnyside:						
Adam McGill Reservoir	83	12/11	21	5.8 ± 3.8	4.3 ±3.2	NA
Wildlife Mgt. Headquarters	84	12/11	27	<1.8	<3.1	NA
Tonopah:						
Jerry's Chevron Station	85	12/ 1	23	<3.1	6.5 ±3.7	NA
Tonopah Test Range CP-1	86	12/ 1	23	<4.1	5.4 ± 3.4	NA
Warm Springs:						
Fallini's Pond	87	12/ 6	21	15 ± 8.3	40 ±5.4	NA
Hot Creek Ranch	88	12/ 6	27	<3.9	11 ±3.8	NA
Service Station and Cafe	89	12/ 5	27	22 ± 8.9	28 ±4.7	NA
Twin Springs Ranch	90	12/ 6	23	9.0 ± 4.7	9.1 ±3.6	NA
Utah:						
Cedar City:						
M. D. Baldwin residence	16	12/ 1	24	<2.6	<3.3	NA
Garrison:						
Rowley Grocery	31	12/13	23	<2.3	<3.1	NA
Newcastle:						
Municipal Reservoir	70	12/ 1	21	<2.2	3.8 ±3.3	NA
Newcastle Dairy	71	12/ 1	24	5.0 ± 4.3	5.4 ±3.7	NA
St. George:						
R. Cox Dairy	82	12/ 1	24	2.6 ± 2.0	<3.5	NA

[a] Two-sigma counting error provided when available.

[b] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water, such as well and spring).
27—Spring.
NA, not analyzed.

Results

The routine analytical results of all water samples collected in December 1972 by the NERC-LV Water Surveillance Network are listed in table 1. No gamma-emitting fission products were detected by gamma spectrometry in any of the samples collected. The analytical results of samples selected for special analyses will be reported at a later date.

Copies of these results are distributed to EPA Regional Offices and appropriate State agencies prior to publication.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports*.

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Plutonium in airborne particulates	July-September 1972	March 1973
Surface air sampling program, 80th Meridian Network, *HASL*	January-December 1970	May 1973

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1. Radiation Alert Network
February 1973

Quality Assurance and Environmental Monitoring Laboratory
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Quality Assurance and Environmental Monitoring Laboratory, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during February 1973.

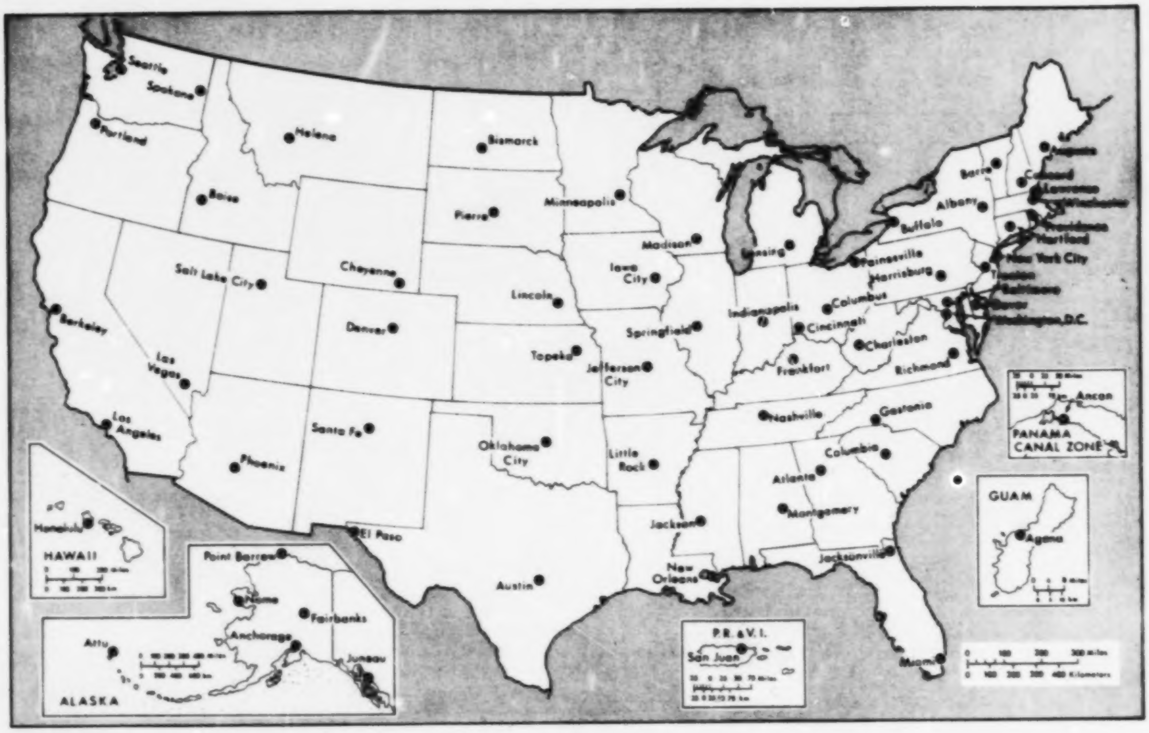
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Madison
Lansing
Iowa City
Denver
Berkeley
Las Vegas
Topeka
Springfield
Indianapolis
Jefferson City
Los Angeles
Santa Fe
Phoenix
Oklahoma City
Little Rock
Nashville
El Paso
Austin
Jackson
New Orleans
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Buffalo
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Painesville
Harrisburg
Columbus
Cincinnati
Charleston
Frankfort
Richmond
Gastonia
Columbia
Atlanta
Montgomery
Jacksonville
Miami
Ancon
PANAMA CANAL ZONE
GUAM
Agana
P.R. & V.I.
San Juan
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
ALASKA

Figure 1. Radiation Alert Network sampling stations

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Table 1. Gross beta radioactivity in surface air and precipitation, February 1973

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation					
			Maximum	Minimum	Average [a]	Number of samples	Total depth (mm)	Field estimation of deposition			
								Number of samples	Depth (mm)	Total deposition (nCi/m³)
Ala:	Montgomery	18	1	0	1	2	101	2	101	11
Alaska:	Anchorage	3	0	0	0	0				
	Attu Island	27	0	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	12	8	0	3	0				
Ark:	Little Rock	0				0				
Calif:	Berkeley	18	0	0	0	8	99	8	99	0
	Los Angeles	18	1	0	0	0				
C.Z:	Ancon	13	0	0	0	0				
Colo:	Denver	18	4	0	1	0		(b)		
Conn:	Hartford	18	0	0	0	5	46	5	46	0
Del:	Dover	18	0	0	0	0				
D.C:	Washington	15	2	0	0	0				
Fla:	Jacksonville	19	1	0	0	3	117	3	117	3
	Miami	2	0	0	0	1	13	1	13	0
Ga:	Atlanta	20	1	0	0	1	93	1	93	10
Guam:	Agana	0				0				
Hawaii:	Honolulu	18	1	0	0	5	25	(b)		
Idaho:	Boise	18	2	0	0	2	16	2	16	1
Ill:	Springfield	4	1	0	0	0				
Ind:	Indianapolis	7	0	0	0	0				
Iowa:	Iowa City	19	1	0	0	2	23	2	23	0
Kans:	Topeka	20	2	0	1	5	37	5	37	1
Ky:	Frankfort	13	1	0	0	0				
La:	New Orleans	19	1	0	0	6	131	(b)		
Maine:	Augusta	17	0	0	0	5	30	5	30	0
Md:	Baltimore	17	1	0	0	6	53	6	53	0
Mass:	Lawrence	19	0	0	0	2	51	2	51	0
	Winchester	19	0	0	0	3	58	3	58	0
Mich:	Lansing	18	0	0	0	0				
Minn:	Minneapolis	19	0	0	0	3	9	3	9	1
Miss:	Jackson	9	0	0	0	4	109	4	109	0
Mo:	Jefferson City	18	1	0	0	0				
Mont:	Helena	14	2	0	1	0				
Nebr:	Lincoln	18	1	0	0	2	36	2	36	10
Nev:	Las Vegas	19	3	0	1	0				
N.H:	Concord	0				0				
N.J:	Trenton	17	1	0	0	6	90	6	90	1
N. Mex:	Santa Fe	15	1	0	0	2	13	2	13	0
N.Y:	Albany	19	2	0	1	0				
	Buffalo	17	0	0	0	0				
	New York City	0				0				
N.C:	Gastonia	17	7	0	2	5	79			
N. Dak:	Bismarck	18	2	0	1	0		(b)		
Ohio:	Cincinnati	0				0				
	Columbus	2	0	0	0	0				
	Painesville	20	0	0	0	9	54	9	54	13
Okla:	Oklahoma City	0				0				
Oreg:	Portland	18	1	0	0	4	58	4	58	1
Pa:	Harrisburg	13	1	0	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	17	0	0	0	0				
S.C:	Columbia	8	1	0	0	2	167	2	167	0
S. Dak:	Pierre	14	3	1	1	0				
Tenn:	Nashville	19	1	0	0	8	87	8	87	0
Tex:	Austin	19	7	1	2	6	58	(b)		
	El Paso	20	5	0	2	0				
Utah:	Salt Lake City	24	1	0	0	3	11	3	11	1
Vt:	Barre	17	0	0	0	5	37	5	37	5
Va:	Richmond	15	1	0	0	5	59	5	59	5
Wash:	Seattle	7	0	0	0	5	35	(b)		
	Spokane	13	1	0	0	0				
W. Va:	Charleston	20	2	0	1	12	53	12	53	6
Wisc:	Madison	20	0	0	0	8	34	8	34	2
Wyo:	Cheyenne	10	1	0	1	0				
Network summary		903	8	0	0	145	61	4	58	3

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

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2. Canadian Air and Precipitation Monitoring Program,[1] February 1973

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for February 1973 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, February 1973

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	3	0.02	0.01	0.01	25	0.5
Coral Harbour	4	.02	.01	.02	27	.3
Edmonton	4	.03	.02	.03	18	.3
Ft. Churchill	3	.04	.03	.03	30	.2
Fredericton	4	.03	.02	.02	5	.5
Goose Bay	4	.02	.01	.02	6	.5
Halifax	4	.03	.01	.02	4	.5
Inuvik	4	.04	.03	.03	112	.5
Montreal	4	.03	.02	.02	9	.6
Moosonee	4	.04	.03	.04	27	.4
Ottawa	4	.03	.02	.03	NS	NS
Quebec	4	.02	.02	.02	6	.7
Regina	4	.03	.02	.02	23	.2
Resolute	4	.04	.03	.04	76	.1
St. John's, Nfld	3	.01	.01	.01	7	1.3
Saskatoon	4	.03	.02	.03	9	.2
Sault Ste. Marie	4	.03	.03	.03	7	.3
Thunder Bay	4	.03	.02	.03	10	.1
Toronto	4	.02	.01	.02	14	.7
Vancouver	4	.01	<.01	.01	12	.8
Whitehorse	4	.03	.01	.02	38	.2
Windsor	4	.02	.02	.02	11	.3
Winnipeg	4	.05	.02	.03	88	.6
Yellowknife	4	.03	.01	.03	25	.2
Network summary	93	0.05	<0.01	0.02	26	0.4

NS, no sample.

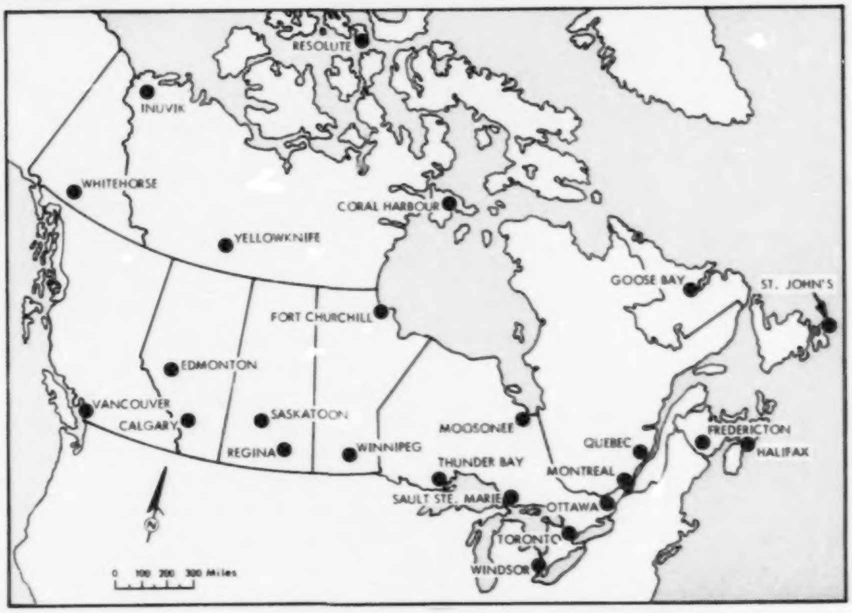
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
0 100 200 300 Miles
N

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program February 1973

Pan American Health Organization and
U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The February 1973 air monitoring results from the participating countries are given in table 3.

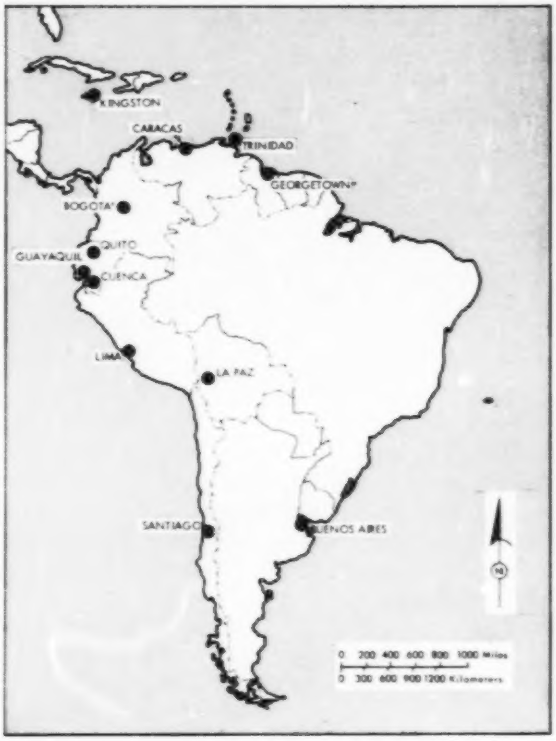

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, February 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	4	0.02	0.02	0.02
Bolivia:	La Paz	6	.02	.00	.01
Chile:	Santiago	26	.05	.01	.02
Colombia:	Bogota	20	.04	.00	.01
Ecuador:	Cuenca	8	.01	.00	.00
	Guayaquil	18	.03	.00	.01
	Quito	3	.01	.00	.00
Guyana:	Georgetown	9	.00	.00	.00
Jamaica:	Kingston	NS			
Peru:	Lima	NS			
Venezuela:	Caracas	12	.01	.00	.00
West Indies:	Trinidad	7	.03	.01	.01
Pan American summary		113	0.05	0.00	0.01

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

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4. California Air Sampling Program February 1973

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continu-

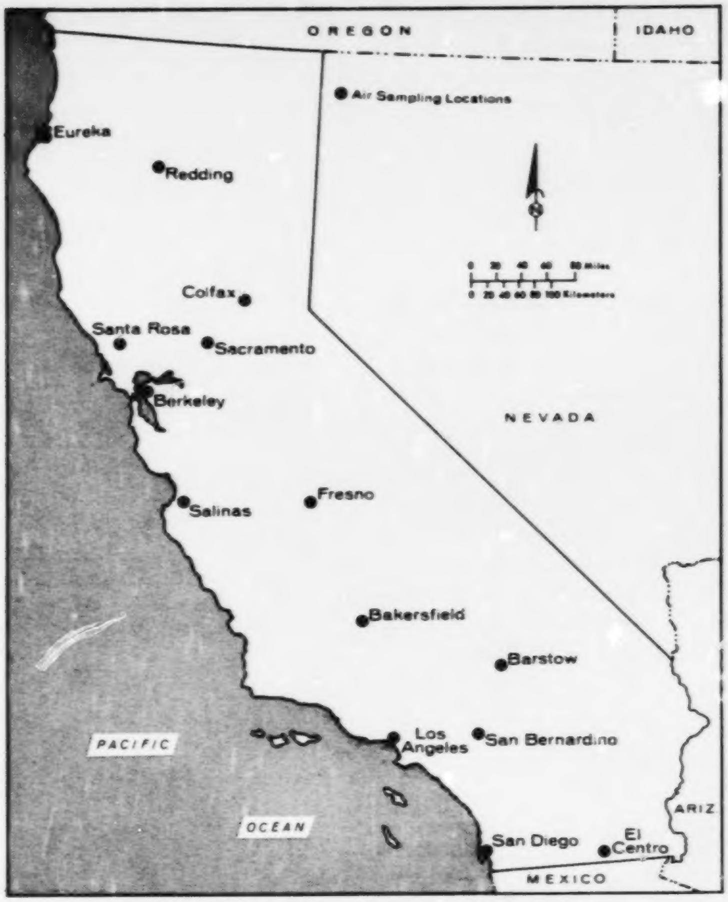
OREGON
IDAHO
Air Sampling Locations
N
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
Los Angeles
San Bernardino
PACIFIC
OCEAN
San Diego
El Centro
ARIZ
MEXICO

Figure 4. California air sampling program stations

ous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity in air for February 1973. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air, February 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	28	0.64	0.01	0.09
Barstow	28	.42	.00	.15
Berkeley	28	.17	.00	.04
Colfax	NS			
El Centro	25	.92	.02	.13
Eureka	28	.13	.00	.03
Fresno	28	.33	.01	.07
Los Angeles	27	.12	.00	.04
Redding	27	.09	.00	.04
Sacramento	28	.24	.00	.04
Salinas	28	.83	.00	.12
San Bernadino	28	.26	.01	.08
San Diego	27	.26	.01	.06
Santa Rosa	26	.12	.00	.05
Summary	356	0.92	0.00	0.07

NS, no sample.

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5. Mexican Air Monitoring Program September-December 1972

Instituto Nacional de Energía Nuclear
México, D.F.

Until December 1971, the Radiation Surveillance Network of Mexico was operated by the Comision Nacional de Energía Nuclear (CNEN).

In December 1971, the CNEN became the Instituto Nacional de Energía Nuclear (INEN), as a result of a new law passed by Congress.

In the Instituto Nacional de Energía Nuclear, the Comité de Seguridad Radiológica (Radiological Security Committee) (CSR) is responsible for radiological protection. The Environmental Radioactivity Section (Sección de Radioactividad Ambiental) of the CSR is in charge of monitoring and measuring environmental radioactive contamination in general, including radiation in mines, uranium milling plant, and the Nuclear Center of Mexico.

Table 5. Mexican gross beta radioactivity of airborne particulates, September-December 1972

Station	Gross beta radioactivity (pCi/m³)			
	September	October	November	December
Chihuahua:				
Maximum	0.1	0.6	0.2	<0.1
Minimum	<.1	<.1	<.1	<.1
Average	<.1	.1	<.1	<.1
Ensenada:				
Maximum	.1	.2	.1	<.1
Minimum	<.1	<.1	<.1	<.1
Average	(a)	.1	.1	(a)
Mérida:				
Maximum	<.1	.1	.1	<.1
Minimum	<.1	<.1	<.1	<.1
Average	<.1	<.1	<.1	<.1
Mexico:				
Maximum	<.1	.5	.1	<.1
Minimum	<.1	<.1	<.1	<.1
Average	<.1	.1	<.1	(a)
Torreón				
Maximum	.1	.7	.1	<.1
Minimum	<.1	<.1	<.1	<.1
Average	<.1	<.1	<.1	<.1
Veracruz:				
Maximum	<.1	.1	.1	<.1
Minimum	<.1	<.1	<.1	<.1
Average	<.1	<.1	<.1	<.1

[a] Average not calculated for less than five samples.

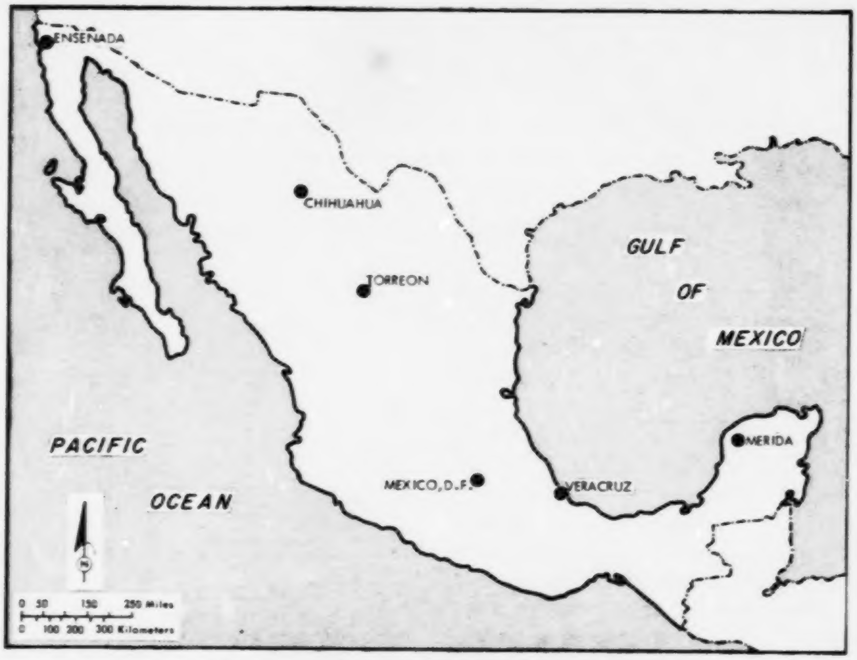

Figure 5. Mexican air sampling locations

Since radioactivity in air particulates have decreased to very low levels in the past few years, the objective of the air monitoring program has been changed from an alert type of network to emphasize dose assessment.

Measurements will continue in the following 6 areas: México City, D.F., Chihuahua, Ensenada, Torreón, Veracruz, and Mérida (figure 5). The sampling and analysis procedures were described previously (*6*).

The maximum, minimum, and average beta radioactivity in surface air from September through December are presented in table 5. Statistically it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*7*).

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6. Plutonium in Airborne Particulates October-December 1972

Office of Radiation Programs
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Division of Atmospheric Surveillance, Environmental Protection Agency, routinely collects airborne particulate samples from 11 selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965, and references to the previous results through December 1969 have been published (*8*).

One-half of each individual air filter from the selected stations is sent to the Eastern Environmental Radiation Facility, Montgomery, Ala. The laboratory analyzes a composite of these samples from each station on a quarterly basis. The results from October to December 1972 are presented in table 6. The minimum detectable activities are 0.020 pCi and 0.015 pCi per sample for plutonium-238 and plutonium-239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

Table 6. Plutonium in airborne particulates October-December 1972

Location		Plutonium-238 (aCi/m^3)	Plutonium-239 (aCi/m^3)	^{239}Pu/^{238}Pu
Alaska:	Anchorage	1.9±0.5	15.4±3.3	8.1± 2.8
Ariz:	Phoenix	1.9± .6	24.7±2.8	13.0± 4.4
Colo:	Denver	1.1± .3	17.1±1.8	15.5± 4.9
Hawaii:	Honolulu	1.3± .4	9.2±1.2	7.1± 2.2
La:	New Orleans	1.2± .4	11.6±1.4	9.7± 3.4
Md:	Baltimore	.2± .1	7.7±1.2	38.5±11.3
N.Y:	Buffalo	1.5± .4	13.4±1.7	8.9± 2.6
N.C:	Gastonia	1.9± .5	10.9±1.3	5.7± 1.6
S. Dak:	Pierre	2.3± .5	9.6±1.2	4.2± 1.1
Tex:	Austin	1.4± .4	12.7±1.5	9.1± 2.8
Wash:	Seattle	.7± .2	13.4±1.8	19.1± 6.8

Other coverage in *Radiation Data and Reports:*

Period	Issue
October-December 1971	July 1972
January-March 1972	December 1972
April-September 1972	January 1973
July-September 1972	March 1973

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) INSTITUTO NACIONAL DE ENERGIA NUCLEAR. Mexican air monitoring program, August-December 1970 and January 1971. Radiol Health Data Rep 12:525-528 (October 1971).

(*7*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963-1965. Comision Nacional de Energía Nuclear, Direccion General de Seguridad Radiologica (1966).

(*8*) BUREAU OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April-December 1969. Radiol Health Data Rep 11:552-553 (October 1970).

Air Surveillance Network, February 1973

National Environmental Research Center—
Las Vegas,[1]
Environmental Protection Agency

The Air Surveillance Network[2] (ASN), operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 49 active and 73 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station (which lies within the NTS), and by the AEC at any other designated testing sites.[2]

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

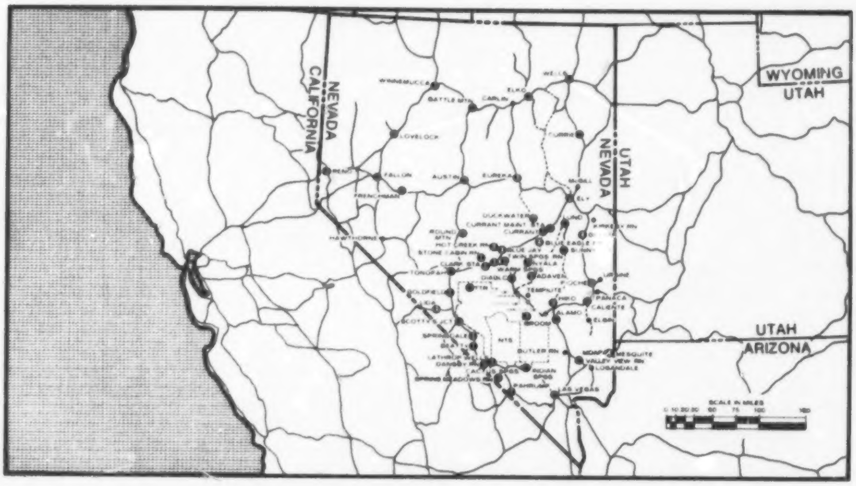
NEVADA
CALIFORNIA
WINNEMUCCA
BATTLE MTN
CARLIN
ELKO
WELLS
LOVELOCK
CURRIE
UTAH
NEVADA
WYOMING
UTAH
RENO
FALLON
AUSTIN
EUREKA
FRENCHMAN
MCGILL
ELY
DUCKWATER
CURRANT MAINT STA
CURRANT
LUND
ROUND MTN
HAWTHORNE
HOT CREEK RN
BLUE JAY
BLUE EAGLE
STONE CABIN RN
TWIN SPGS RN
SUNNY
CLARK STA
NYALA
WARM SPGS
TONOPAH
DIABLO
ADAVEN
PIOCHE
URSINE
TEMPIUTE
GOLDFIELD
HIKO
PANACA
CALIENTE
ALAMO
SCOTTYS JCT
ELGIN
SPRINGDALE
NTS
BEATTY
BUTLER RN
MOAPA
MESQUITE
VALLEY VIEW RN
LOGANDALE
INDIAN SPGS
PAHRUMP
LAS VEGAS
UTAH
ARIZONA
SCALE IN MILES

Figure 1. NERC-LV Air Surveillance Network stations in Nevada

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[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

Results

Table 1 presents the monthly average gross beta concentrations in air for each of the network stations. The highest gross beta concentration within the network was less than 0.2 pCi/m^3 at Alamo and Round Mountain, Nev., and Delta, Utah. Because of low sample volumes (approximately 50 percent of normal) due to power outages at those three stations, the minimum detectable concentrations were 0.2 pCi/m^3. The minimum reporting concentration for gross beta is 0.1 pCi/m^3. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06 pCi/m^3) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reporting level (0.1 pCi/m^3) are reported as <0.1 pCi/m^3. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during February 1973.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC–LV upon written request.

Table 1. Summary of gross beta radioactivity concentrations in air, February 1973

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average [a]
Ariz:	Kingman	28	<0.1	<0.1	<0.1
	Seligman	28	<.1	<.1	<.1
Calif:	Baker	23	.1	<.1	<.1
	Barstow	28	<.1	<.1	<.1
	Bishop	28	<.1	<.1	<.1
	Death Valley Junction	28	<.1	<.1	<.1
	Furnace Creek	27	<.1	<.1	<.1
	Long Pine	24	<.1	<.1	<.1
	Needles	20	<.1	<.1	<.1
	Ridgecrest	28	<.1	<.1	<.1
	Shoshone	28	<.1	<.1	<.1
Nev:	Alamo	28	<.2	<.1	<.1
	Austin	24	<.1	<.1	<.1
	Beatty	26	<.1	<.1	<.1
	Blue Eagle Ranch (Currant)	28	<.1	<.1	<.1
	Blue Jay	28	<.1	<.1	<.1
	Caliente	28	<.1	<.1	<.1
	Currant Ranch	28	<.1	<.1	<.1
	Diablo	28	<.1	<.1	<.1
	Duckwater	27	<.1	<.1	<.1
	Ely	28	<.1	<.1	<.1
	Eureka	28	<.1	<.1	<.1
	Fallini's Twin Springs Ranch	28	<.1	<.1	<.1
	Geyser Maintenance Station	28	<.1	<.1	<.1
	Goldfield	28	<.1	<.1	<.1
	Groom Lake	19	.1	<.1	<.1
	Hiko	28	<.1	<.1	<.1
	Indian Springs	28	<.1	<.1	<.1
	Las Vegas	19	<.1	<.1	<.1
	Lathrop Wells	28	<.1	<.1	<.1
	Lida	28	<.1	<.1	<.1
	Lund	27	<.1	<.1	<.1
	Mesquite	28	<.1	<.1	<.1
	Nyala	28	<.1	<.1	<.1
	Pahrump	26	<.1	<.1	<.1
	Pioche	28	<.1	<.1	<.1
	Round Mountain	28	<.2	<.1	<.1
	Scotty's Junction	27	<.1	<.1	<.1
	Stone Cabin Ranch	28	<.1	<.1	<.1
	Sunnyside	20	<.1	<.1	<.1
	Tonopah	27	<.1	<.1	<.1
	Tonopah Test Range	21	<.1	<.1	<.1
	Warm Springs	28	<.1	<.1	<.1
	Warm Springs Ranch	28	<.1	<.1	<.1
Utah:	Cedar City	27	<.1	<.1	<.1
	Delta	28	<.2	<.1	<.1
	Garrison	28	<.1	<.1	<.1
	Milford	27	<.1	<.1	<.1
	St. George	28	<.1	<.1	<.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m^3 is reported a <0.1.

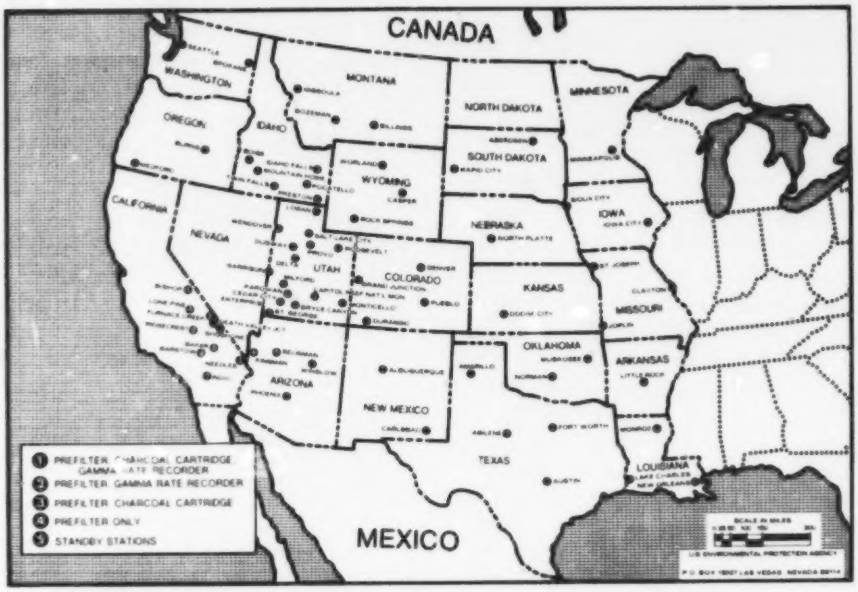
CANADA
WASHINGTON
SEATTLE
SPOKANE
MONTANA
MISSOULA
BOZEMAN
BILLINGS
NORTH DAKOTA
MINNESOTA
MINNEAPOLIS
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
SOUTH DAKOTA
ABERDEEN
RAPID CITY
WYOMING
WORLAND
CASPER
ROCK SPRINGS
CALIFORNIA
NEVADA
WENDOVER
LOGAN
SALT LAKE CITY
DUGWAY
PROVO
ROOSEVELT
DELTA
UTAH
GARRISON
MILFORD
PAROWAN
CEDAR CITY
ENTERPRISE
CAPITOL REEF NAT'L MON
BRYCE CANYON
ST. GEORGE
MONTICELLO
GRAND JUNCTION
COLORADO
DENVER
PUEBLO
DURANGO
NEBRASKA
NORTH PLATTE
IOWA
SIOUX CITY
IOWA CITY
ST. JOSEPH
KANSAS
DODGE CITY
MISSOURI
CLAYTON
JOPLIN
BISHOP
LONE PINE
FURNACE CREEK
RIDGECREST
DEATH VALLEY JCT
SHOSHONE
BAKER
BARSTOW
NEEDLES
INDIO
SELIGMAN
KINGMAN
WINSLOW
ARIZONA
PHOENIX
ALBUQUERQUE
NEW MEXICO
CARLSBAD
AMARILLO
OKLAHOMA
MUSKOGEE
NORMAN
ARKANSAS
LITTLE ROCK
ABILENE
FORT WORTH
MONROE
TEXAS
AUSTIN
LOUISIANA
LAKE CHARLES
NEW ORLEANS
MEXICO
① PREFILTER CHARCOAL CARTRIDGE GAMMA RATE RECORDER
② PREFILTER GAMMA RATE RECORDER
③ PREFILTER CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS
SCALE IN MILES
U.S. ENVIRONMENTAL PROTECTION AGENCY
P.O. BOX 15027 LAS VEGAS, NEVADA 89114

Figure 2. NERC-LV Air Surveillance Network stations outside Nevada

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follow for the Knolls Atomic Power Laboratory.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Knolls Atomic Power Laboratory[2]
January-December 1971

General Electric Company
Schenectady, N.Y.

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission (AEC), is to support the AEC in the development and testing of nuclear reactors for power plants. This includes design, construction, operation, and maintenance of prototype nuclear power reactors. The Knolls Atomic Power Laboratory consists of two sites, the Knolls and the Kesselring site, located as shown in figure 1.

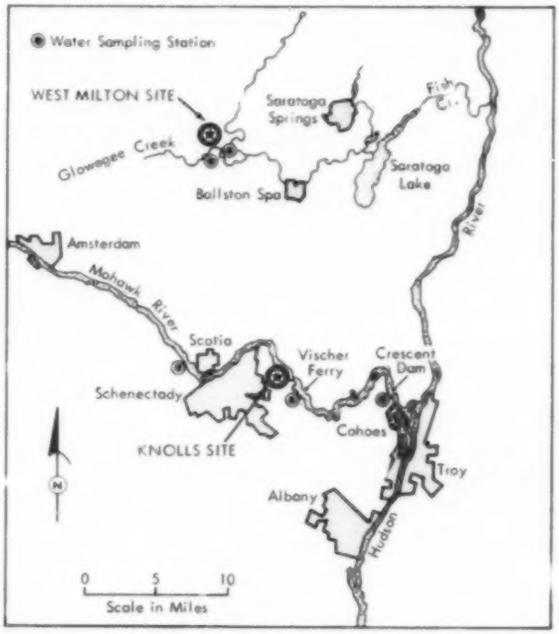
● Water Sampling Station
WEST MILTON SITE
Saratoga Springs
Fish Cr.
Glowegee Creek
Ballston Spa
Saratoga Lake
Amsterdam
Mohawk River
River
Scotia
Schenectady
Vischer Ferry
Crescent Dam
Cohoes
KNOLLS SITE
N
Troy
Albany
Hudson
0
5
10
Scale in Miles

Figure 1. Environmental monitoring locations, XAPL

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[2] Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission, Knolls Site and Kesselring Site," January-December 1971.

Knolls site

The Knolls site is located 5 miles east of Schenectady, N.Y., on the south bank of the Mohawk River. It consists of approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings.

The Knolls site releases of radioactive materials both to the atmosphere and to the Mohawk River are limited to the lowest practicable amounts below the AEC standards. Prior to the release, exhaust air and liquid waste are treated and carefully monitored. In addition to the inplant control monitoring, an environmental monitoring program is conducted to detect environmental trends related to Knolls site operations and to ascertain compliance with the radioactivity standards established by the AEC.

Air monitoring

Potentially radioactive exhaust air from Knolls site operations is filtered and monitored prior to discharge to the environment. Noble gases, according to detailed conservative analyses, result in an offsite exposure corresponding to less than 0.05 percent of the external radiation protection standard for an individual member of the offsite population. Continuous filter samples of the effluent are collected and these samples are analyzed on a weekly basis for gross alpha and beta-gamma activity and for selected radionuclides. Monitoring results for 1971 indicate a total discharge of 0.62 mCi consisting of 0.05 mCi of alpha particulate activity, 0.53 mCi of beta-gamma particulate activity and 0.04 mCi of iodine–131. During 1971, the radioactivity concentration in the effluent from the stacks averaged less than 3 percent of the appropriate environmental concentration guide for air as given in AEC Manual Chapter 0524.

Mohawk River and municipal waters

Continuous samples of Mohawk River water were collected at the General Electric Company powerhouse, 8 miles upriver from the Knolls site, and at the Vischer Ferry powerhouse, 1.7 miles downriver, as shown in figure 1. Weekly aliquots of each river sample were composited and analyzed on a monthly basis. In addition, grab samples of Schenectady municipal water were collected and analyzed. The samples were analyzed for gross alpha with alpha proportional counters and for gross beta-gamma activity using thin mica end-window geiger counters. In addition, municipal water was analyzed for strontium–90, if the gross beta-gamma concentration exceeded 10 pCi/liter; this did not occur during 1971. Each analysis involves radiation counting of dry mounts prepared by appropriate chemical procedures; i.e., an extraction technique for alpha analysis, an evaporation procedure employing nitric acid for beta-gamma analysis, and a separation procedure for strontium–90 analysis.

The radioactivity monitoring results for Mohawk River water and Schenectady municipal water for 1971 are summarized in table 1. The results show no statistical differences between the radioactivity concentration in river water upstream and downstream of the Knolls site or between river water samples and samples of municipal water. The gross beta-gamma radioactivity and the gross alpha radioactivity concentrations averaged less than 1.5 percent and 0.014 percent, respectively, of the applicable environmental concentration guide for water, as determined from AEC radiation protection standards. The data presented in table 1 and the foregoing comparison indicate that the small amount of radioactivity discharged during 1971 had no discernable effects on the environmental radioactivity levels in Mohawk River and municipal waters.

Mohawk River bottom sediment

The Knolls site Mohawk River sediment monitoring program involved the collection and analyses of sediment samples in each of three calendar quarters; ice coverage prevents collection during the first calendar quarter. Bottom samples were collected at the upriver and downriver locations from the Knolls site with a Birge-Ekman Dredge from areas 6 inches by 6

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Table 1. Radioactivity in Mohawk River water and Schenectady municipal water, Knolls site, 1971 [a]

Location and source of water sampled	Number of samples	Total radioactivity concentration (pCi/liter)					
		Alpha			Beta-gamma		
		Maximum	Minimum	Average	Maximum	Minimum	Average
General Electric Powerhouse, 8 miles upriver	52	<1.1 (MDA)	<0.17 (MDA)	<0.65	6.3 ±4.4	<3.6 (MDA)	<4.7
Vischer Ferry, 1.7 miles downriver	52	<1.1 (MDA)	.26 ± .25	<.68	<5.0 (MDA)	<3.9 (MDA)	<4.6
Schenectady municipal water	11	<1.1	<.23 (MDA)	<.68	<4.9 (MDA)	4.0 ±3.6	<4.6

[a] Minimum detectable activity (MDA) values and the statistical precision (±) values are expressed at the 95-percent confidence level.

inches to an average depth of 1 inch. All samples were analyzed for gross alpha activity by the extraction technique, for gross beta-gamma by direct counting of a dried aliquot of the sample, and for gamma emitters by gamma spectrum analysis. Selected samples are also analyzed for strontium–90 by isotopic separation technique. The radioactivity monitoring results for Mohawk River bottom sediment for 1971 are summarized in table 2.

The data presented in table 2 indicate that the radioactivity concentration in sediment downriver from the Knolls site is generally higher than the concentration upriver. This resulted from liquid effluent releases prior to 1964, when the activity discharged per year was up to 7,000 times higher than in recent years. Of the total radioactivity released from the Knolls site, over 99 percent was discharged prior to 1964.

Perimeter monitoring

Environmental monitoring thermoluminescent dosimeters are posted on the Knolls site security fence. The results of this monitoring show that the general public did not receive radiation exposure greater than natural background as a result of Knolls site operations.

Kesselring site

The Kesselring site, located on approximately 3,900 acres near West Milton, N.Y., is a part of the Knolls Atomic Power Laboratory. Its

Table 2. Radioactivity concentrations in Mohawk River sediment,[a] Knolls site, 1971

Area sampled relative to effluent point	Number of samples	Total radioactivity (pCi/g wet weight)					
		Alpha			Beta		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Upriver	6	0.39 ±0.10	0.14 ±0.07	0.25 ±0.06	26 ±5.7	12 ±4.9	19 ±3.0
Downriver	36	.69 ± .15	.12 ± .06	.33 ± .05	31 ±5.5	9 ±4.8	17 ±3.0
Opposite	3	.31 ± .08	.28 ± .08	.29 ± .05	20 ±5.0	14 ±5.1	17 ±3.0
		Cesium-137 (pCi/g wet weight)			Strontium-90 (pCi/g wet weight)		
Upriver	3	.96 ± .68	[b] ≤ .44	≤ .62 ± .32	[b] ≤ .23	[b] ≤ .21	≤ .22 ± .18
Downriver	3	3.1 ± .94	[b] ≤ .29	≤ .94 ± .33	.40 ± .27	[b] ≤ .21	≤ .27 ± .15
Opposite	3	1.4 ± .65	[b] ≤ .45	≤ .80 ± .33	[b] ≤ .21	[b] ≤ .21	≤ .21 ± .14

[a] Multiply values by 2.3 to convert to units of pCi/g (dry weight).

[b] Minimum detectable activity values and the statistical precision (±) values are expressed at the 95-percent confidence level.

principal facilities include the S3G and D1G prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards.

Water monitoring

All Glowegee Creek water analysis results were below the minimum detectable activity concentration that may be considered valid at the 90-percent confidence level. During the report period, a new analytical technique lowered the minimum detectable activity from 50 pCi/liter to 4.5 pCi/liter with a maximum error of ± 100 percent at the 90-percent confidence level. The results show no statistically significant difference between the radioactivity concentration in Glowegee Creek water upstream and downstream from the site.

Sediment monitoring

Glowegee Creek sediment radioactivity measurements are analyzed by gamma radiation spectrometry on a monthly basis. Sample locations are the same as those listed for Glowegee Creek water sampling. The minimum detectable activity (MDA) for cobalt-60 is 0.1 pCi/g of sediment while the MDA for the gross gamma radioactivity analysis is 0.2 pCi/g of sediment. These MDA's are based on average height and density values of sediment samples obtained using a 90-percent confidence level for the error. The samples are taken by scooping up 2 inches of sediment from the creek bottom. At least 500 grams are required for each sample. Table 3 presents the sediment analysis results.

The results show no statistically significant difference between the radioactivity concentration in Glowegee Creek sediment upstream and downstream from the site.

Table 3. Radioactivity in Glowegee Creek sediment Kesselring site, January–December 1971

Location	Number of samples	Gross gamma radioactivity[*] (pCi/g dry weight)		Cobalt-60 (pCi/g dry weight)
		Average	Range	Average
Upstream	9	13.0	9.1-16.9	1.9
Downstream	10	14.3	8.8-19.4	2.0

[*] Primarily potassium-40.

Environmental radiation monitoring

In addition to the air exhaust stack radioactivity monitoring, surveys are made semiannually of the radiation levels at the Kesselring site perimeter. Perimeter surveys performed during the year showed normal background radiation levels for the geographic location. The result of the perimeter survey extrapolated to an annual exposure indicates average perimeter radiation levels of <0.1 roentgen per year. It is concluded that Kesselring site operations did not significantly contribute to the natural background radiation of the surrounding area.

Effluent monitoring

Liquid effluent released from the Kesselring site is collected, processed, and sampled prior to release to the Glowegee Creek. During discharge each retention basin is sampled when one half of the liquid is discharged and again just prior to completion. The water returned to the Glowegee Creek in 1971 contained less than 0.92 mCi of radioactivity. This results in an average concentration of less than 0.006 percent of the appropriate AEC standards.

Air released from power plant and radiological support buildings is continuously monitored for air particulate activity. The activity is collected on high efficiency filter paper and the activity is analyzed for beta-gamma activity. The total airborne particulate radioactivity discharged to the environment during the calendar year 1971 was less than 2 pCi. This resulted in an average concentration of less than 1.5 percent of the appropriate AEC standard. The only gaseous radionuclide of concern, argon-41, has a half life of less than 2 hours and does not build-up in the environment.

It is concluded from the effluent monitoring results that Kesselring site operations are effective in protecting the environment and the public health.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-December 1970	January 1973

Nuclear Power Reactors in the United States
March 31, 1973

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of *Radiation Data and Reports.*

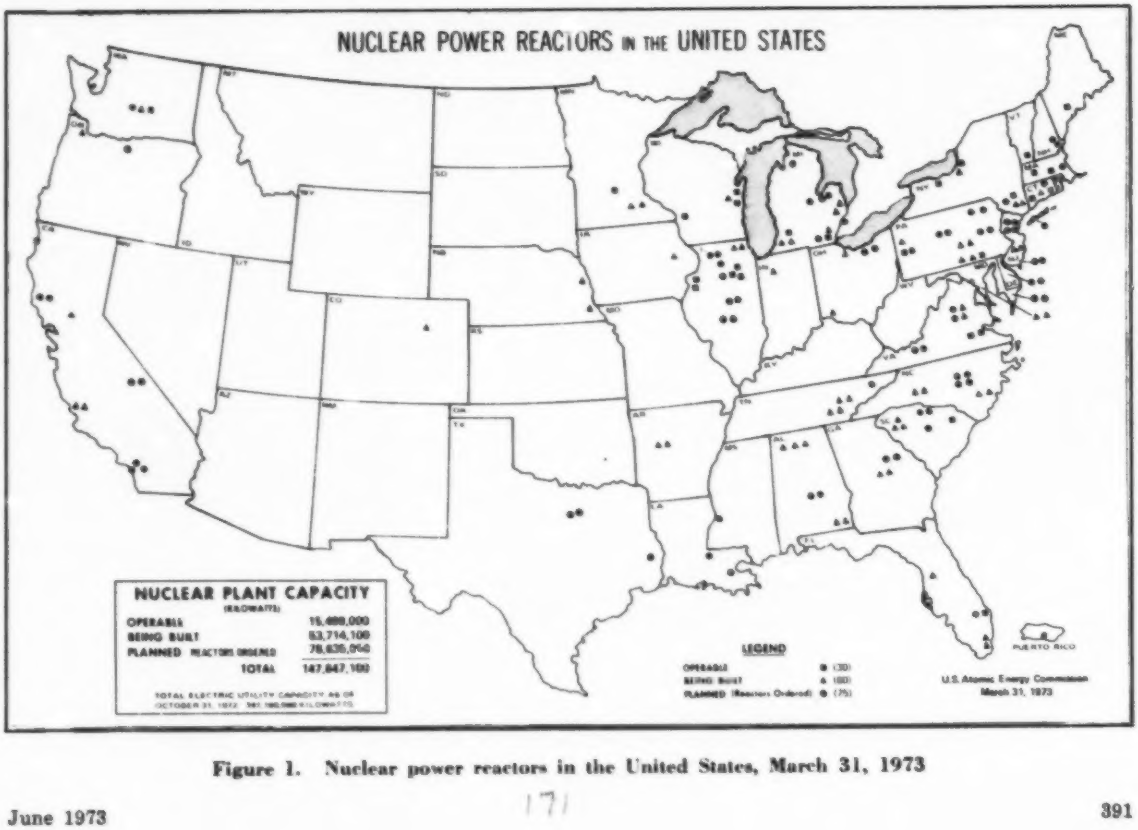
NUCLEAR POWER REACTORS IN THE UNITED STATES
NUCLEAR PLANT CAPACITY
(KILOWATTS)
OPERABLE 15,498,000
BEING BUILT 53,714,100
PLANNED REACTORS ORDERED 78,635,000
TOTAL 147,847,100
TOTAL ELECTRIC UTILITY CAPACITY AS OF OCTOBER 31, 1972
LEGEND
OPERABLE ● (30)
BEING BUILT ▲ (80)
PLANNED (Reactors Ordered) ● (75)
PUERTO RICO
U.S. Atomic Energy Commission
March 31, 1973

Figure 1. Nuclear power reactors in the United States, March 31, 1973

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SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1974
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
Selma	Orville: Unit 1	1,100,000	Alabama Power Co.	1981
Selma	Orville: Unit 2	1,100,000	Alabama Power Co.	1982
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	820,000	Arkansas Power & Light Co.	1973
Russellville	Arkansas Nuclear One: Unit 2	902,000	Arkansas Power & Light Co.	1976
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1967
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	—
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas and Electric Co.	1974
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas and Electric Co.	1975
Clay Station	Rancho Seco Nuclear Generating Station	804,000	Sacramento Municipal Utility District	1974
Pt. Arena	Mendocino Power Plant: Unit 1	1,128,000	Pacific Gas & Electric Co.	1978
Pt. Arena	Mendocino Power Plant: Unit 2	1,128,600	Pacific Gas & Electric Co.	1979
-		720,000	Southern California Edison Co.	1981
-		770,000	Southern California Edison Co.	1982
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1973
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
Waterford	Millstone Nuclear Power Station: Unit 3	1,150,000	Northeast Utilities	1979
DELAWARE				
Middletown	Delmarva Unit 1	770,000	Delmarva Power & Light Co.	1978
Middletown	Delmarva Unit 2	770,000	Delmarva Power & Light Co.	1981
FLORIDA				
Florida City	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Florida City	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1973
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1973
Ft. Pierce	St. Lucie Plant: Unit 1	801,000	Florida Power & Light Co.	1975
Ft. Pierce	St. Lucie Plant: Unit 2	801,000	Florida Power & Light Co.	1979
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1973
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	795,000	Georgia Power Co.	1976
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,121,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,121,000	Georgia Power Co.	1979
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1977
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1978
Byron	Byron Station: Unit 1	1,120,000	Comm. Edison Co.	1979
Byron	Byron Station: Unit 2	1,120,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 1	1,100,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 2	1,100,000	Comm. Edison Co.	1981
Clinton	Clinton Nuclear Power Plant	950,000	Comm. Edison Co.	1980
Clinton	Clinton Nuclear Power Plant	950,000	Comm. Edison Co.	1982-3
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1977
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	529,700	Iowa Electric Light and Power Co.	1973
LOUISIANA				
Taft	Waterford Generating Station	1,165,000	Louisiana Power & Light Co.	1976
St. Francisville	River Bend Station	934,000	Gulf States Utilities Co.	1979

Figure 1. Nuclear power reactors in the United States—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1974
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1974
Douglas Point	Douglas Point Project: Unit 1	1,178,000	Potomac Electric Power Co.	1980
Douglas Point	Douglas Point Project: Unit 2	1,178,000	Potomac Electric Power Co.	1981
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	664,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,180,000	Boston Edison Co.	1978
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1976
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,125,000	Detroit Edison Co.	1980
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1973
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1974
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1977
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1978
St. Clair County	Greenwood: Unit 2	1,240,000	Detroit Edison Co.	1979
St. Clair County	Greenwood: Unit 3	1,240,000	Detroit Edison Co.	1981
Quanicassee	Quanicassee: Unit 1	1,150,000	Consumers Power Co.	1981
Quanicassee	Quanicassee: Unit 2	1,150,000	Consumers Power Co.	1981
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1973
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station	1,290,000	Mississippi Power & Light Co.	1978
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1973
NEW HAMPSHIRE				
Seabrook	—	1,100,000	Public Service of N.H.	1979
Seabrook	—	1,100,000	Public Service of N.H.	1981
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	640,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,070,000	Jersey Central Power & Light Co.	1978
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N.J.	1974
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N.J.	1975
Bordentown	Newbold Nuclear Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N.J.	1978
Bordentown	Newbold Nuclear Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N.J.	1979
Little Egg Inlet	Atlantic Generating Station: Unit 1	1,150,000	Public Service Electric and Gas, N.J.	1980
Little Egg Inlet	Atlantic Generating Station: Unit 2	1,150,000	Public Service Electric and Gas, N.J.	1981
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1973
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1970
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R. E. Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1975
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1977
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1980

Figure 1. Nuclear power reactors in the United States—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	906,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
Painesville	Perry Nuclear Power Plant: Unit 1	1,100,000	Cleveland Electric Illuminating Co.	1979
Painesville	Perry Nuclear Power Plant: Unit 2	1,100,000	Cleveland Electric Illuminating Co.	1980
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1976
OREGON				
Prescott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1975
Boardman		1,200,000	Portland General Electric Co.	1980
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1973
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1978
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1979
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	852,000	Duquesne Light Co. Ohio Edison Co.	1974
Shippingport	Beaver Valley Power Station: Unit 2	852,000	Duquesne Light Co. Ohio Edison Co.	1978
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1973
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Jersey Central Power & Light Co.	1975
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1981
*	Philadelphia Electric Co. HTGR No. 1	1,140,000	Philadelphia Electric Co.	1979
*	Philadelphia Electric Co. HTGR No. 2	1,140,000	Philadelphia Electric Co.	1981
SOUTH CAROLINA				
Hartsville	H. B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	841,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
Broad River	Virgil C. Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1977
Lake Wylie	Catawba Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1979
Lake Wylie	Catawba Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1980
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1975
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1977
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1978
Oak Ridge	Fast Breeder Demonstration Plant	400,000	Tennessee Valley Authority	1980
TEXAS				
Glen Rose	Commanche Peak Steam Electric Station: Unit 1	1,150,000	Texas Power & Light Co.	1980
Glen Rose	Commanche Peak Steam Electric Station: Unit 2	1,150,000	Texas Power & Light Co.	1982
Newton County	Blue Hills: Unit 1	950,000	Gulf States Utilities	1980
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1973
Mineral	North Anna Power Station: Unit 1	898,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	898,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 3	900,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	900,000	Virginia Electric & Power Co.	1978
*	–	900,000	Virginia Electric & Power Company	1980
*	–	900,000	Virginia Electric & Power Company	1981
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	800,000	Atomic Energy Commission	1966
Richland	WPPSS No. 1	1,120,000	Washington Public Power Supply System	1980
Richland	WPPSS No. 2	1,103,000	Washington Public Power Supply System	1977
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	53,200	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1971
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Michigan Power Co.	1972
PUERTO RICO				
Puerto De Jobos	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1975
*	–	1,189,000	Tennessee Valley Authority	1977
*	–	1,189,000	Tennessee Valley Authority	1978
*	–	1,120,000	Tennessee Valley Authority	1980
*	–	1,120,000	Tennessee Valley Authority	1981
*	–	1,120,000	Tennessee Valley Authority	1981
*	–	1,120,000	Tennessee Valley Authority	1982

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* Site not selected.

Figure 1. Nuclear power reactors in the United States—continued

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Reported Nuclear Detonations, May 1973

(Includes seismic signals presumably from foreign nuclear detonations)

There were no nuclear detonations reported for the United States by the U.S. Atomic Energy Commission for May 1973.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

SUMMARY OF ENVIRONMENTAL MONITORING AT PHILADELPHIA, 1958–1971. *J. E. Lieberman, R. D. Ice, M. Green*, and *R. McGrattan, Radiation Data and Reports, Vol.* 14, June 1973, pp. 333–350.

The City of Philadelphia maintains an environmental radiation surveillance program for evaluating the environment of the Delaware Valley. The program has evolved from the initial goals of setting operational guides for the collection and analyses of data at sites of nuclear ship operations, through preoperational radiological data collection associated with the construction of the N.S. Savannah, through a nuclear weapons fallout evaluation to the present objective of providing environmental surveillance of nuclear facilities.

A 13-year compilation of environmental data from the City of Philadelphia is presented. Included are gross alpha and gross beta results of raw and finished surface waters, gross beta results of air samples, and strontium-90, and iodine-131 quantities in pasteurized milk.

KEYWORDS: Air, barium-140, Chinese and French bomb tests, gross alpha, gross beta, iodine-131, lanthanide, milk, N.S. *Savannah*, Philadelphia, Pa., radioactivity, strontium-89, strontium-90, water, yttrium.

JOINT DENTAL RADIATION SURVEY IN PUERTO RICO, 1968. *Michael Gileadi. Radiation Data and Reports, Vol.* 14, June 1973. pp. 351–355.

The objective, scope, and methods used in the 1968 Joint Dental Survey Project, sponsored jointly by the Health Department of Puerto Rico, Puerto Rico Nuclear Center and School of Dentistry, University of Puerto Rico, are described. Health hazards associated with dental x-ray diagnostic procedures in Puerto Rico 1968 are evaluated, and relevant statistical and technical data pertinent to the use of x rays in the dental profession on the Island are presented.

KEYWORDS: Dental, x rays, Puerto Rico